FIFTY-EIGHTH ANNUAL REPORT

OF THE

SECRETARY

OF THE

State Board of Agriculture

OF THE

STATE OF MICHIGAN

AND

THIRTY-SECOND ANNUAL REPORT

OF THE

EXPERIMENT STATION

FROM

JULY 1, 1918, TO JUNE 30, 1919

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FORT WAYNE, INDIANA
1920

REPORT OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

EAST LANSING, MICH., *July 1, 1919.*

TO HON. ALBERT E. SLEEPER,

Governor of the State of Michigan:

SIR—I have the honor to submit to you herewith, as required by law, the accompanying report for the fiscal year ending June 30, 1919, with supplementary papers.

Very respectfully,

ADDISON M. BROWN,

Secretary of the State Board of Agriculture.

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° Absent on leave.
* Resigned.
§ Deceased Dec. 6, '18.
‡ Deceased Feb. 27, '19.
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*Resigned.
**Returned from military service.

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MICHIGAN AGRICULTURAL COLLEGE

FOR THE YEAR ENDING JULY 30, 1919.

SECRETARY'S FINANCIAL REPORT

			Dr.	Cr.
July 1, 1918.	Cash on hand		$9,555 72	
July 1, 1918.	Cash on deposit, College Treasurer, overdrawn			$4,149 30
June 30, 1919.	To special appropriation receipts		468,027 61	
	From State Treasurer	$ 89,470 34		
	From United States Treasurer	350,198 54		
	From Institution and other sources	28,358 73		
June 30, 1919.	By disbursements			469,117 66
	Special appropriations	252,680 83		
	Experiment Station	93,282 67		
	Extension	123,154 16		
June 30, 1919.	To current account receipts		844,890 40	
	From State Treasurer, land grant interest	70,662 44		
	From State Treasurer, one-fifth mill tax	478,687 04		
	$560,000 00			
	(a) 81,312 96			
	From United States Treasurer, Morrill Fund	50,000 00		
	From Institution and other sources	237,357 07		
	From South Haven Experiment Station	530 81		
	From U. P. Experiment Station	7,653 04		
	By general account disbursements			836,692 13
June 30, 1919.	By cash on hand			6,489 66
June 30, 1919.	By cash on deposit			6,024 98
			$1,322,473 73	$1,322,473 73

(a) Appropriated for Extension 51,312 96
Appropriated for Experiment Station 30,000 00

TABLE NO. I.—*Tabular Exhibit of Secretary's Reports.*

	Balance sheet, July 1, 1918.		Transactions July 1, 1918 to June 30, 1919.		Balance sheet, June 30, 1919.	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Cash	$9,555 72		$3,066 06		$6,489 66	
* College Treasurer		$4,149 30		$10,174 28	6,024 98	
Special appropriations	7,719 28		257,818 33	252,680 83	2,581 78	
Current accounts		21,011 23	844,890 40	836,692 13		$29,209 50
Experiment Station	5,081 33		84,250 92	93,282 67	14,113 08	
Extension	2,804 20		125,958 36	123,154 16		
Totals	$25,160 53	$25,160 53	$1,315,984 07	$1,315,984 07	$29,209 50	$29,209 50

* Treasurer's statement is greater July 1, 1918 by $24,627.60 and June 30, 1919, $18,641.34; *warrants outstanding.*

TREAURER'S ACCOUNT

	Dr.	Cr.
Balance on hand July 1, 1918	$20,478 28	
Receipts from State Treasurer and Secretary of the College	1,325,542 79	
Interest on deposits during year	1,081 24	
Warrants paid July 1, 1918 to June 30, 1919		$1,322,435 99
Balance on hand June 30, 1919		24,666 32
Totals	$1,347,102 31	$1,347,102 31

TABLE NO. II.—*Statement of special appropriation accounts for the fiscal year ending June 30, 1919.*

	Balance of accounts *July 1, 1918.*		Receipts during fiscal year.				Balance of accounts *June 30, 1919.*	
	Dr.	Cr.	From State Treasurer.	From Institution and other sources.	Total available.	Total expended.	Dr.	Cr.
Experiment Station	$5,081 33		(a) $60,000 00	$24,250 92	$79,169 59	$93,282 67	$14,113 08	
Extension	2,804 20		(b) 124,426 27	1,532 09	123,154 16	123,154 16		
Lawson Memorial Fund	12 50			25 00	12 50	25 00	12 50	
Allen Scholarship				1,047 22	1,047 22	1,010 84		$36 38
Gymnasium		$3,094 79			3,094 79	3,094 79		
Nursery				1,478 50	1,478 50	1,478 50		
Sayer Fund		37 20		25 00	62 20	50 00		12 20
Shop and Storehouse						1,297 44	1,297 44	
U. S. Army School	11,180 91		(c) 245,731 91	1,353 32	235,904 32	238,750 86	2,846 54	
Vocational Teachers' Training			7,157 38		7,157 38	6,022 65		1,134 73
Weather Service		342 14	1,000 00		1,342 14	950 75		391 39
Totals	$19,078 94	$3,474 13	$438,315 56	$29,712 05	$452,422 80	$469,117 66	$18,269 56	$1,574 70

(a) $ 30,000.00 U. S. Treasurer. (b) $73,113.31 U. S. Treasurer. (c) $245,731.91 U. S. Treasurer.

TABLE NO. 3.—*William Smith Sayer Scholarship Fund.*

Fund.	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$500.00 received of F. F. Sayer, administrator of the estate of William Smith Sayer, to establish Scholarship in Bacteriology..	1910	$32 25	A. McVittie...	$19 75	$512 20
	1911	37 50	....	....	550 00
	1912	12 50	D. K. Fisher.. H. K. Wright.	25 00 25 00	512 50
	1913	25 00	D. Francisco..	25 00	512 50
	1914	24 85	R. W. Waffle..	25 00	512 35
	1915	24 85	J. D. Baker...	25 00	512 20
	1916	25 00	J. M. Mase...	25 00	512 20
	1917	25 00	Elsa Scheuren.	25 00	512 20
	1918	25 00	....	....	537 20
	1919	25 00	Elwyn Younker Ethel Hoppban	25 00	512 20
Total..	....	$256 95	....	$244 75	....

TABLE NO. 4.—*George E. Lawson Memorial Prize.*

Fund.	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$500.00 received of John W. Beaumont, in memory of Geo. E. Lawson, to offer annual cash prize for the best essay in English produced by male student............................	1917	$25 00	I. B. McMurty	$25 00	$500 00
	1918	12 50	H. C. Diehl...	25 00	487 50
	1919	25 00	Stanley Powell	25 00	487 50
Total..	....	$62 50	....	$75 00	....

TABLE NO. 5.—*Geo. L. Allen Scholarship.*

Fund.	Year ending June 30	Income.	Income expended.	Amount.	Balance including principal
$1,000.00 received of Amanda A. Ransom to be used in assisting the poor and deserving young men in obtaining their education.	1919	....	....	....	$1,036 38
Total..	....	....	....	....	$1,036 38

TABLE NO. 6.—*Current Account July 1, 1918 to June 30, 1919.*

On account of—	Dr. To disbursements.	Cr By receipts.
U. S. Treasurer, 29th annual payment under act of Congress, of Aug., 1890		$50,000 00
State Treasurer, one-fifth mill fund		478,687 04
State Treasurer, interest on proceeds of sales of U. S. land grant		70,662 44
Agricultural Education	$224 57	
Anatomy	1,293 32	433 24
Animal Husbandry	19,740 77	15,168 16
Bacteriology	9,854 43	2,776 43
Botany	3,273 20	815 45
Chemistry	15,571 43	7,704 67
Civil Engineering	1,109 80	127 00
Dairy Husbandry	62,122 42	59,679 26
Drawing	1,583 13	724 64
Domestic Art	2,351 90	908 55
Domestic Science	4,904 54	1,901 59
Economics	128 86	5 00
Electrical Engineering	3,166 21	83 00
English	233 29	22 40
Entomology	2,485 26	443 45
Farm Crops	2,364 76	583 35
Farm and Horses	28,955 55	19,720 64
Farm Mechanics	2,275 84	906 50
Forestry	3,645 08	2,324 58
History	108 66	2 00
Horticulture	13,014 64	3,030 92
Library	2,884 32	1 00
Mathematics	404 45	90 75
Mechanical Engineering	10,675 73	1,947 97
Meteorology	77 74	13 00
Military Science	1,305 10	88 05
Pathology	1,281 32	5 00
Physical Training	13,686 61	4,223 23
Physics	6,175 24	2,352 79
Poultry	8,756 19	3,324 91
Soils	2,609 81	113 71
Special Courses	9,907 74	2,450 00
Surgery and Clinic	4,374 66	559 22
Veterinary Science	1,090 17	43 00
Zoology	561 55	352 50
Advertising	2,415 69	16 30
Alumni Recorder	1,509 56	
Bulletins	12,943 32	
Cleaning	11,968 23	2,167 36
Contingent Building	110,804 00	a62,030 92
Dean of Agriculture	1,233 77	90 00
Dean of Engineering	1,383 81	
Dean of Home Economics	6,933 49	564 90
Dean of Summer School	656 72	48 00
Electric Lighting	12,569 15	3,701 29
Freight and Cartage	2,373 74	8 55
Heating	63,951 14	2,160 53
Hospitals	8,060 73	1,546 81
Miscellaneous	3,840 51	2,590 61
Office, President's	2,410 49	1,202 05
Office, Secretary's	6,186 59	2,045 38
Registrar	2,812 40	75 00
Salaries	308,314 50	24,881 16
Seed Analysis	106 15	81 00
Telephones	2,083 09	321 25
South Haven Experiment Station	3,101 17	530 81
Upper Peninsula Experiment Station	28,835 59	7,653 04
Totals	$836,692 13	$844,890 40
Balance beginning fiscal year, July 1, 1918	....	21,011 23
Balance on hand June 30, 1919	29,209 50	....
Totals	$865,901 63	$865,901 63

aDiploma fees, $685.00; incidentals, $6,167.50; matriculation, $1,450.00; room rent, $13,754.28; tuition, $3,888.00; delinquent $289.50; supplies, $17,230.99; labor, $3,948.57; land, $12,272.30; sundry, $2,353.80.

DISTRIBUTION OF SPECIAL APPROPRIATIONS.

On account of—	Dr. To disbursements.	Cr. By receipts.
Weather Service	$950 75	$1,000 00
Nursery License and Inspection	1,478 50	1,478 50
Sayer Fund	50 00	25 00
Gymnasium	3,094 79	
Geo. E. Lawson Memorial Fund	25 00	25 00
Geo. L. Allen Scholarship	1,010 84	1,047 22
Shops and Storehouse	1,297 44	
U. S. Army School	238,750 86	247,085 23
Vocational Teachers Training	6,022 65	7,157 38
Totals	$252,680 83	$257,818 33
Balance overdrawn beginning Fiscal Year, July 1, 1918	7,719 28	
Balance overdrawn June 30, 1919		2,581 78
Totals	$260,400 11	$260,400 11

TABLE NO. 7.—*Experiment Station account for fiscal year ending June 30, 1919.*

	Disbursements.			Dr. Total disbursements each department.	Cr. By receipts.
	Adams.	Hatch.	State.		
Balance overdrawn July 1, 1918				$5,081 33	
U. S. Treasurer					$30,000 00
State Treasurer, one-fifth mill fund					30,000 00
Fertilizer Fees			$1,518 76	1,518 76	7,170 00
Commercial Feeding Stuffs			1,472 46	1,472 46	14,975 00
Animal Husbandry			41 51	41 51	
Bacteriological	$2,858 65	$928 09	3,571 66	7,358 40	456 63
Botanical	103 60	37 20	3,720 75	3,861 55	158 57
Chemical		189 90	4,469 65	4,659 75	55 36
Dairy Husbandry			1,160 38	1,160 38	
Directors Office		20 00	1,474 84	1,494 84	56 53
Entomological		93 74	402 74	496 48	
Farm Crops		547 24	4,235 82	4,783 06	441 01
Graham Horticulture			3,027 19	3,027 19	907 70
Horticulture		422 34	1,663 61	2,085 95	3 72
Library		403 51	8 00	411 51	
Salaries	12,037 75	11,473 65	33,021 19	56,532 59	
Secretaries Office			294 00	294 00	
Soils		884 33	3,200 11	4 084 44	26 40
Balance overdrawn June 30, 1919					14,113 08
Totals	$15,000 00	$15,000 00	$63,282 67	$98,364 00	$98,364 00

TABLE NO. 8.—*Extension Account for fiscal year ending June 30, 1919.*

On account of projects	Disbursements.			Dr. Total disbursements for each project.	Cr. By receipts.
	Lever.	Lever State.	State.		
Balance overdrawn July 1, 1918	....	....	....	$2,804 20	....
U. S. Treasury Lever Fund	....	....	....	....	$73,113 31
State Treasurer, one-fifth Mill Fund, Lever State	....	....	....	....	43,710 48
State Treasurer, one-fifth Mill Fund, State	....	....	....	....	7,602 48
Administration	$7,472 57	$3,174 93	$246 10	10,893 60	51 88
Boys' and Girls' Club Work	5,037 42	6,497 67	841 88	12,376 97	75 71
Control of Insect Pests	3,057 97	1,338 07	89 56	4,485 60	....
County Agents	23,439 32	5,072 97	205 43	28,717 72	388 75
Dairy Husbandry	665 67	341 52	7 30	1,014 49	....
Extension Schools	3,186 82	504 79	13 65	3,705 26	102 34
Farm Crops	3,599 69	2,447 31	211 70	6,258 70	12 10
Farmers' Week	....	....	*1,997 30*	*1,997 30*	....
Farm Management Demonstration	835 60	3,176 48	411 22	4,423 30	695 28
Forestry	*1,172 36*	*337 82*	....	*1,510 18*	....
Home Economics	8,820 28	5,934 95	511 98	15,267 21	129 56
Horticulture	1,401 71	509 97	26 60	1,938 28	....
Household Engineering	1,840 90	791 05	105 57	2,737 52	....
Live Stock	2,417 53	2,508 85	240 41	5,256 79	74 65
Markets	1,551 71	2,359 40	2,368 44	6,279 55	....
Muck Crop Demonstrations	1,830 23	1,970 05	160 17	3,960 45	1 38
Potatoes and Vegetables	3,160 83	1,268 39	77 08	4,506 30	44
Poultry	3,178 24	2,661 02	94 46	5,933 72	....
Publications	820 96	1,069 76	25	1,890 97	....
Soils	....	25	....	25	....
Balance on hand, June 30, 1919	....	....	....	....	....
Total	$73,489 81	$42,055 25	$7,609 10	$125,958 36	$125,958 36

Vouchers on file from counties for $19,402.83 as offset to Smith Lever Fund.

TABLE NO. 9.—*Positions and salaries as shown by pay-roll dated June 30, 1919.*

Grade.	Rate per year.	Classification. Current.	Experiment Station.	Extension.
Administration and Miscellaneous:				
President's Office:				
President	$6,500 00	$6,500 00		
Clerk	1,750 00	1,750 00		
Stenographer	1,000 00	1,000 00		
Secretary's Office:				
Secretary	b2,200 00	1,500 00	$700 00	
Cashier	2,500 00	2,300 00	200 00	
Bookkeeper	1,000 00	900 00	100 00	
Clerk	850 00	850 00		
Clerk	850 00	850 00		
Clerk	850 00	850 00		
Purchasing Agent	2,500 00	2,500 00		
Registrar's Office:				
Registrar	1,750 00	1,750 00		
Clerk	1,150 00	1,150 00		
Library:				
Librarian	1,700 00	1,580 00	120 00	
Assistant Librarian	1,150 00	1,150 00		
Assistant	900 00	900 00		
Miscellaneous:				
Engineer	1,800 00	1,800 00		
Night Watchman	870 00	870 00		
Architect	2,500 00	2,500 00		
Stenographer	850 00	850 00		
Stenographer	850 00	850 00		
Stenographer	720 00	720 00		
Secretary Y. M. C. A.	500 00	500 00		
Director of Band	1,500 00	1,500 00		
Instructor of Meteorology	350 00	350 00		
Medical Officer	1,200 00	1,200 00		
Division of Home Economics:				
Dean's Office:—Dean	2,800 00	2,800 00		
Advisor of Women	c1,600 00	1,600 00		
Stenographer	850 00	850 00		
Department of Domestic Art:				
Professor	2,200 00	2,200 00		
Instructor	c1,200 00	1,200 00		
Instructor	1,000 00	1,000 00		
Instructor	1,200 00	1,200 00		
Instructor	1,500 00	1,500 00		
Instructor	780 00	780 00		
Department of Domestic Science:				
Assistant Professor	1,500 00	1,500 00		
Instructor	1,200 00	1,200 00		
Instructor	c1,500 00	1,500 00		
Instructor	c900 00	900 00		
Graduate Assistant	500 00	500 00		
Miscellaneous:				
Instructor in Music	1,300 00	1,300 00		
Hostess Eunomian House	540 00	540 00		
Assistant to Dean and Instructor Physical Culture	c1,150 00	1,150 00		
Matron	800 00	800 00		
Matron	950 00	950 00		
Matron	350 00	350 00		
House Director	c1,050 00	1,050 00		
House Mother	600 00	600 00		
Hostess Hesperian House	525 00	525 00		
Division of Engineering:				
Dean's Office:				
Dean	a3,500 00	3,500 00		
Clerk	900 00	900 00		

TABLE NO. 9.—*Continued.*

Grade.	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Department of Drawing and Design:				
Professor	$3,000 00	$3,000 00		
Associate Professor	2,100 00	2,100 00		
Associate Professor	2,000 00	2,000 00		
Assistant Professor	1,800 00	1,800 00		
Assistant Professor	1,800 00	1,800 00		
Instructor	1,500 00	1,500 00		
Instructor	1,200 00	1,200 00		
Instructor	1,300 00	1,300 00		
Instructor	780 00	780 00		
Department of Civil Engineering:				
Professor	a2,700 00	2,700 00		
Associate Professor	2,500 00	2,500 00		
Assistant Professor	1,900 00	1,900 00		
Assistant Professor	1,900 00	1,900 00		
Instructor	1,800 00	1,800 00		
Instructor	1,600 00	1,600 00		
Department of Mechanical Engineering:				
Professor	3,000 00	3,000 00		
Assistant Professor	2,100 00	2,100 00		
Instructor	1,300 00	1,300 00		
Instructor Forge Shop	1,300 00	1,300 00		
Foreman Forge Shop	2,000 00	2,000 00		
Foreman Pattern Shop	1,700 00	1,700 00		
Foreman Machine Shop	2,200 00	2,200 00		
Foreman Foundry	1,350 00	1,350 00		
Shop Engineer	1,000 00	1,000 00		
Department of Electrical Engineering:				
Professor	3,000 00	3,000 00		
Assistant Professor	2,000 00	2,000 00		
Assistant Professor	1,800 00	1,800 00		
Division of Science and Letters:				
Department of Bacteriology:				
Professor	3,000 00	2,300 00	$700 00	
Research Associate Professor	2,000 00	1,100 00	900 00	
Instructor	2,000 00	1,000 00	1,000 00	
Graduate Assistant	500 00	500 00		
Graduate Assistant	250 00	250 00		
Instructor	1,800 00	1,400 00	400 00	
Instructor	1,500 00	1,500 00		
Department of Botany:				
Professor	2,700 00	2,500 00	200 00	
Associate Professor	2,250 00	2,250 00		
Associate Professor	2,400 00	1,250 00	1,150 00	
Research Associate Professor	2,250 00	800 00	1,450 00	
Assistant Professor	1,900 00	1,900 00		
Assistant Professor	1,700 00	1,700 00		
Graduate Assistant	500 00	500 00		
Instructor	1,500 00	1,500 00		
Stenographer	850 00	850 00		
Department of Chemistry:				
Professor	3,000 00	3,000 00		
Associate Professor	2,800 00	2,800 00		
Associate Professor	2,500 00	2,500 00		
Assistant Professor	2,300 00	2,300 00		
Assistant Professor	1,800 00	1,800 00		
Instructor	1,700 00	1,700 00		
Instructor	1,600 00	1,600 00		
Instructor	950 00	950 00		
Instructor	1,600 00	1,600 00		
Instructor	1,250 00	1,250 00		
Instructor	1,250 00	1,250 00		
Instructor	1,500 00	1,500 00		
Stenographer	950 00	950 00		
Dispensing Clerk	1,200 00	1,200 00		
Instructor	1,350 00	1,350 00		
Instructor	1,500 00	1,500 00		

TABLE No. 9—*Continued.*

Grade.	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Department of English:				
Professor	a$2,700 00	$2,700 00	....	....
Associate Professor	2,100 00	2,100 00	....	....
Assistant Professor	2,000 00	2,000 00	....	....
Instructor	1,400 00	1,400 00	....	....
Instructor	1,400 00	1,400 00	....	....
Instructor	1,400 00	1,400 00	....	....
Instructor	1,700 00	1,700 00	....	....
Instructor	1,600 00	1,600 00	....	....
Instructor	1,600 00	1,600 00	....	....
Instructor	2,200 00	2,200 00	....	....
Department of Economics:				
Professor	3,000 00	3,000 00	....	....
Associate Professor	2,000 00	2,000 00	....	....
Department of Entomology:				
Professor	a2,700 00	2,300 00	$400 00	....
Instructor	1,550 00	1,150 00	400 00	....
Inspector Apiaries	600 00	600 00	....	....
Stenographer	850 00	850 00	....	....
Department of History:				
Professor	3,300 00	3,000 00	....	....
Instructor	1,500 00	1,500 00	....	....
Department of Mathematics:				
Professor	3,000 00	3,000 00	....	....
Associate Professor	2,400 00	2,400 00	....	....
Assistant Professor	1,800 00	1,800 00	....	....
Assistant Professor	1,700 00	1,700 00	....	....
Assistant Professor	1,900 00	1,900 00	....	....
Instructor	1,600 00	1,600 00	....	....
Department of Military Science:				
Professor	1,500 00	1,500 00	....	....
Assistant Professor	720 00	720 00	....	....
Physical Culture:				
Professor	4,500 00	4,500 00	....	....
Instructor	c1,100 00	1,100 00	....	....
Department of Physics:				
Professor	3,000 00	3,000 00	....	....
Associate Professor	2,000 00	2,000 00	....	....
Instructor	1,200 00	1,200 00	....	....
Department of Zoology:				
Professor	a2,700 00	2,700 00	....	....
Assistant Professor	1,900 00	1,900 00	....	....
Assistant Professor	1,900 00	1,900 00	....	....
Assistant Professor	1,900 00	1,900 00	....	....
Instructor	1,700 00	1,700 00	....	....
Instructor	1,500 00	1,500 00	....	....
ivision of Veterinary Science:				
Veterinary Department:				
Dean	3,300 00	3,300 00	....	....
Assistant Professor	1,900 00	1,900 00	....	....
Stenographer	720 00	720 00	....	....
Surgery and Clinic:				
Associate Professor	2,500 00	2,500 00	....	....
Department of Pathology:				
Associate Professor	2,700 00	200 00	2,500 00	....
Instructor	1,800 00	1,800 00	....	....
Department of Anatomy:				
Professor	2,700 00	2,700 00	....	....
Assistant Professor	1,500 00	1,500 00	....	....
ivision of Agriculture:				
Dean's Office:				
Dean	a3,800 00	2,300 00	1,500 00	....
Stenographer	850 00	500 00	350 00	....

TABLE No. 9—*Continued.*

Grade.	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Department of Animal Husbandry:				
Professor	$2,500 00	$2,100 00	$400 00	....
Instructor	2,000 00	2,000 00	....	....
Herdsman	1,200 00	1,200 00	....	....
Stenographer	720 00	720 00	....	....
Department of Dairy Husbandry:				
Professor	3,000 00	2,800 00	200 00	....
Assistant Professor	2,500 00	2,500 00	....	....
Assistant Professor	1,700 00	1,700 00	....	....
Instructor	1,500 00	1,500 00	....	....
Clerk	780 00	780 00	....	....
Stenographer	850 00	850 00	....	....
Department of Farm Crops:				
Professor	2,500 00	1,800 00	700 00	....
Assistant	1,200 00	1,200 00	....	....
Instructor	2,400 00	450 00	1,950 00	....
Instructor	1,700 00	1,700 00	....	....
Stenographer	720 00	720 00	....	....
Department of Farm Mechanics:				
Professor	2,500 00	1,950 00	550 00	....
Instructor	1,300 00	1,300 00	....	....
Department of Farm and Horses:				
Superintendent	1,800 00	1,800 00	....	....
Department of Poultry Husbandry:				
Associate Professor	2,400 00	1,800 00	600 00	....
Poultry Man	1,200 00	1,200 00	....	....
Instructor	1,600 00	1,600 00	....	....
Department of Forestry:				
Professor	3,000 00	2,800 00	200 00	....
Associate Professor	2,400 00	2,400 00	....	....
Foreman Forest Nursery	1,100 00	1,100 00	....	....
Stenographer	800 00	800 00	....	....
Department of Horticulture:				
Professor	3,000 00	2,300 00	700 00	....
Assistant Professor	1,900 00	1,900 00	....	....
Assistant Professor	1,800 00	1,600 00	200 00	....
Professor	a3,000 00	2,100 00	900 00	....
Department of Soils:				
Professor	3,000 00	2,400 00	600 00	....
Associate Professor	2,150 00	2,150 00	....	....
Assistant Professor	2,100 00	1,050 00	1,050 00	....
Assistant Professor	2,100 00	2,100 00	....	....
Instructor	1,500 00	1,500 00	....	....
Department of Telegraphy:				
Instructor	1,500 00	1,500 00	....	....
Experiment Station:				
Botany Department:				
Assistant Plant Breeding	1,200 00	....	1,200 00	....
Chemistry Department:				
Chemist	3,000 00	....	3,000 00	....
Assistant Chemist	1,350 00	....	1,350 00	....
Research Assistant	2,050 00	....	2,050 00	....
Assistant	1,550 00	....	1,550 00	....
Assistant	1,000 00	....	1,000 00	....
Assistant	1,000 00	....	1,000 00	....
Research Chemist	2,200 00	....	2,200 00	....
Chief Inspector Fertilizers and Feeds	1,750 00	....	1,750 00	....
Inspector Fertilizers and Feeds	1,600 00	....	1,600 00	....
Inspector Fertilizers and Feeds	1,200 00	....	1,200 00	....
Stenographer	950 00	....	950 00	....
Bulletin Clerk	800 00	....	800 00	....

TABLE No. 9—*Continued.*

Grade.	Rate per year.	Classification. Current.	Classification. Experiment Station.	Extension.
Dairy Department:				
Assistant	$1,800 00	....	$1,800 00	....
Field Accountant	1,300 00	....	1,300 00	....
Assistant	1,500 00	....	1,500 00	....
Inspector—Milk Production	1,100 00	....	1,100 00	....
Entomology Department:				
Research Assistant	2,000 00	....	2,000 00	....
Farm Crops Department:				
Farm Crops Breeder	2,000 00	....	2,000 00	....
Assistant in Breeding	1,200 00	....	1,200 00	....
Horticultural Department:				
Assistant	1,900 00	....	1,900 00	....
Live Stock:				
Experimenter	2,500 00	....	2,500 00	....
Soils Department:				
Research Assistant	1,250 00	....	1,250 00	....
Investigator	1,400 00	....	1,400 00	....
Bacteriology:				
Research Associate	2,000 00	....	2,000 00	....
Research Assistant	1,800 00	....	1,800 00	....
Division of Extension:				
Administration:				
Director	2,800 00	....	....	$2,800 00
Clerk	1,050 00	....	....	1,050 00
Stenographer	800 00	....	....	800 00
County Agents:				
State Leader	1,980 00	....	....	1,980 00
Assistant State Leader	2,300 00	....	....	2,300 00
Assistant State Leader	300 00	....	....	300 00
Agent Chippewa Co.	1,080 00	....	....	1,080 00
Agent Delta County	1,080 00	....	....	1,080 00
Agent Dickinson County	1,080 00	....	....	1,080 00
Agent Iron County	1,080 00	....	....	1,080 00
Agent Kent County	700 00	....	....	700 00
Agent Marquette County	600 00	....	....	600 00
Agent Manistee County	600 00	....	....	600 00
Agent Missaukee County	1,080 00	....	....	1,080 00
Agent Newaygo County	600 00	....	....	600 00
Agent Osceola County	1,800 00	....	....	1,800 00
Agent Ottowa County	1,080 00	....	....	1,080 00
Agent Presque Isle County	1,080 00	....	....	1,080 00
Agent Schoolcraft County	1,800 00	....	....	1,800 00
Agent Oceana County	1,800 00	....	....	1,800 00
Stenographer	850 00	....	....	850 00
Home Economics:				
Specialist	1,600 00	....	....	1,600 00
Specialist	1,400 00	....	....	1,400 00
Specialist in Health	1,600 00	....	....	1,600 00
Assistant	1,400 00	....	....	1,400 00
Stenographer	750 00	....	....	750 00
Boys' and Girls' Clubs:				
State Leader	800 00	....	....	800 00
Assistant	700 00	....	....	700 00
Assistant	1,150 00	....	....	1,150 00
Stenographer	820 00	....	....	820 00
Extension Schools:				
Superintendent	1,600 00	....	....	1,600 00
Farm Crops:				
Specialist	1,800 00	....	....	1,800 00
Specialist	1,600 00	....	....	1,600 00
Stenographer	850 00	....	....	850 00
Live Stock:				
Specialist	700 00	....	....	700 00
Assistant	600 00	....	....	600 00

TABLE No. 9—*Continued.*

Grade.	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Horticulture:				
Specialist	$2,000 00	....	....	$2,000 00
Assistant	2,000 00	....	....	2,000 00
Potatoes and Vegetables:				
Specialist	2,400 00	....	....	2,400 00
Specialist	1,600 00	....	....	1,600 00
Muck Crops:				
Specialist	1,800 00	....	....	1,800 00
Farm Management Demonstrations:				
Demonstrator	1,200 00	....	....	1,200 00
Assistant	120 00	....	....	120 00
Control of Insect Pests:				
Specialist	1,800 00	....	....	1,800 00
Specialist in Apiculture	1,200 00	....	....	1,200 00
Household Engineering:				
Specialist	1,800 00	....	....	1,800 00
Forestry:				
Specialist	1,700 00	....	....	1,700 00
Poultry:				
Specialist	1,800 00	....	....	1,800 00
Specialist	1,000 00	....	....	1,000 00
Markets:				
Specialist	500 00	....	....	500 00
Field Agent	1,300 00	....	....	1,300 00
Accountant	1,450 00	....	$125 00	1,325 00
Publication Clerk	750 00	....	....	750 00
Assist. Leader in Home:				
Demonstration	240 00	....	....	240 00
Dairy Specialist	2,500 00	....	....	2,500 00
Total	$445,645 00	$314,055 00	$61,645 00	$69,945 00

a—House.
b—Other sources $1,000.00. House.
c—Use of rooms.

TABLE NO. 10.—*Salaries Experiment Station, fiscal year ending June 30, 1919.*

Director	$1,500 00
Bacteriologist	700 00
Research Associate in Bacteriology	2,000 00
Research Assistant in Bacteriology	1,800 00
Research Assistant in Bacteriology	300 00
Research Assistant in Bacteriology	375 00
Research Assistant in Bacteriology	111 24
Assistant in Bacteriology	413 90
Assistant in Bacteriology	374 90
Animal Pathologist	2,500 00
Assistant in Animal Pathology	464 70
Botanist	200 00
Associate Botanist	1,150 00
Research Associate in Botany	412 50
Research Associate in Plant Pathology	1,450 05
Assistant in Plant Pathology	466 70
Chemist	2,999 95
Research Associate in Chemistry	1,100 00
Research Associate in Chemistry	2,050 00
Assistant in Chemistry	1,550 00
Assistant in Chemistry	1,000 00
Assistant in Chemistry	831 60
Assistant in Chemistry	539 25
Assistant in Chemistry	27 42
Assistant in Chemistry	19 50
Chief Inspector in Fertilizers and Feeds	1,750 00
Inspector in Fertilizers and Feeds	1,600 00
Inspector in Fertilizers and Feeds	900 00
Animal Husbandman	400 10
Dairy Husbandman	200 00
Assistant in Dairying	1,800 00
Assistant in Dairying	691 67
Accountant in Milk Product	1,214 29
Field Inspector in Milk Products	914 60
Entomologist	400 00
Research Associate in Entomology	2,000 00
Assistant in Entomology	400 00
Farm Crops Experimenter	525 00
Research Associate in Crop Breeding	1,949 95
Superintendent Crop Experiments	900 00
Associate in Farm Mechanics	550 00
Forester	200 00
Vice Director and Horticulturist	900 00
Horticulturist	700 00
Research Associate in Horticulture	1,000 00
Assistant in Horticulture	200 00
Assistant in Horticulture	1,899 95
Associate Poultry Husbandman	600 00
Soils Physicist	600 60
Research Associate in Soils	1,562 50
Research Associate in Soils	1,050 00
Investigator in Soils	470 60
Librarian	120 00
Secretary	700 00
Cashier	200 00
Bookkeeper	97 82
Chie Clerk	125 00
Stenfographer	950 00
Sten ographer	350 00
Bulletin Clerk	800 00
Live Stock Experimenter	2,500 00
Fiber Investigator	974 20
Total	$56,532 59

TABLE NO. 11.—*Salaries Extension, fiscal year ending June 30, 1919.*

Administration:	
Director	$2,800 00
Clerk	1,050 00
Stenographer	800 00
Superintendent of Publications	900 00
Stenographer	750 00
Accountant	1,308 20
County Agents:	
State Leader	1,724 98
Assistant State Leader	163 20
Assistant State Leader, U. P.	1,462 45
Agent, Allegan County	239 69
Agent, Alpena County	104 26
Agent, Berrien County	352 21
Agent, Branch County	239 69
Agent, Cheboygan County	464 19
Agent, Chippewa County	1,012 46
Agent, Delta County	1,012 46
Agent, Dickinson County	899 94
Agent, Gogebic County	239 69
Agent, Houghton County	239 69
Agent, Iron County	849 44
Agent, Kent County	859 16
Agent, Lenawee County	239 69
Agent, Manistee County	368 94
Agent, Marquette County	600 00
Agent, Mason County	352 21
Agent, Menominee County	520 46
Agent, Missaukee County	1,012 46
Agent, Muskegon County	374 20
Agent, Newaygo County	600 00
Agent, Oceana County	745 00
Agent, Osceola County	745 00
Agent, Ottowa County	1,012 46
Agent, Presque Isle County	1,012 46
Agent, Saginaw County	249 50
Agent, Schoolcraft County	745 00
Agent, St. Clair County	249 50
Agent, St. Joseph County	249 50
Agent, Van Buren County	298 40
Agent, Wayne County	374 20
Agent, Wexford County	249 50
Stenographer	850 00
Home Economics:	
Specialist in Charge	1,600 00
Specialist	932 10
Specialist	33 60
Assistant	1,400 00
Assistant	101 00
Assistant	99 30
Specialist in Health	1,330 40
Stenographer	750 00
Extension Schools:	
Superintendent	1,600 00
Boys' and Girls' Club Work:	
State Leader	275 00
State Leader	665 20
Assistant State Leader	1,150 00
Assistant State Leader	409 00
Assistant State Leader	89 60
Stenographer	850 00
Stenographer	200 00
Farm Crops:	
Specialist	1,800 00
Assistant Specialist	577 76
Stenographer	829 20
Live Stock:	
Specialist	700 00
Assistant Specialist	600 00
Horticulture:	
Specialist	335 20
Specialist	891 35
Potatoes and Vegetables:	
Specialist	2,400 00
Specialist	777 78
Stenographer	15 63

TABLE No. 11—*Continued.*

Control of Muck Diseases:	
Specialist	$1,350 60
Farm Management Demonstration:	
Specialist	700 60
Assistant	90 00
Control Insect Pests:	
Specialist	1,800 00
Household Engineering:	
Specialist	1,800 00
Markets:	
Director	1,327 80
Specialist	500 00
Specialist	476 71
Poultry:	
Specialist	1,800 00
Assistant	1,000 00
Forestry:	
Specialist	850 00
Dairy:	
Specialist	1,644 40
Agriculture:	
Specialist	1,200 00
Total	$63,261 82

TABLE No. 12—*Income of the Michigan Agricultural College from all outside sources from the date of its foundation to the present time.*

Year.	From State Legislature.			From U. S. Congress.				Total
	For current expenses.	For special purposes.	Land sales, salt spring and swamp land grants.	Morrill act of 1862, interest from land grant and trespass.	Hatch act of 1887, and Adams act of 1906, experiment station.	Morrill act of 1890, supplementary endowment.	Smith Lever act of 1914, extension.	
1855			$56,320 00					$56,320 00
1856								
1857	$40,000 00							40,000 00
1858								
1859	37,500 00							37,500 00
1860								
1861	6,500 00		152 25					6,652 25
1862	10,000 00		218 97					10,218 97
1863	9,000 00		407 80					9,407 80
1864	9,000 00		726 09					9,726 09
1865	15,000 00		1,156 61					16,156 61
1866	15,000 00		1,094 27					16,094 27
1867	20,000 00		7,608 38					27,608 38
1868	20,000 00		592 49					20,592 49
1869	20,000 00	$30,000 00	17,559 00	$58 96				67,617 96
1870	20,000 00		1,320 02	2,720 93				24,040 95
1871	18,250 00	10,500 00	4,135 72	3,785 54				36,671 26
1872	18,250 00	3,000 00	217 05	7,175 65				28,642 70
1873	21,796 00	15,602 00	10 13	11,059 06				48,467 19
1874	13,000 00	15,602 00	150 13	14,061 98				42,814 11
1875	7,638 00	7,755 50	144 53	14,446 14				29,984 17
1876	7,638 00	6,755 50	1,773 09	16,830 17				32,996 76
1877	6,150 00	30,686 80	979 06	15,172 86				52,988 72
1878	6,150 00	5,686 80	826 60	15,807 09				28,470 49
1879	4,971 80	16,068 32	712 22	16,978 22				38,730 56
1880	4,971 80	7,068 32	797 55	17,837 24				30,674 91
1881	7,249 00	43,720 50	461 95	20,935 25				72,366 70
1882	7,249 00	8,945 50	358 46	22,507 45				39,060 41
1883	8,385 00	23,793 00	391 95	30,749 80				63,319 52
1884	8,385 00	10,526 00	1,259 90	27,909 72				48,080 65

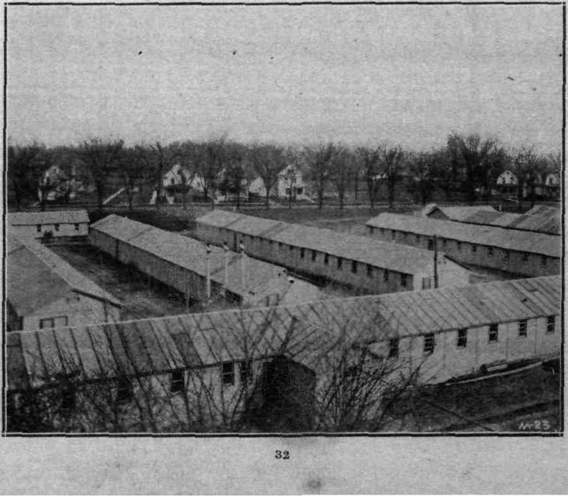
1885	....	35,103 00	187 50	29,770 40	....	....	....	65,060 90
1886	....	22,617 00	....	30,461 04	....	....	....	53,078 04
1887	....	*44,040 00	198 20	†24,611 37	....	....	....	68,849 57
1888	....	30,752 50	144 20	32,406 60	$15,000 00	....	....	78,303 30
1889	....	*20,973 00	10 50	31,322 69	15,000 00	....	....	67,306 19
1890	....	*27,172 00	238 50	32,360 64	15,000 00	$15,000 00	....	89,771 14
1891	....	22,947 50	37 38	34,750 54	15,000 00	16,000 00	....	88,735 42
1892	....	22,947 50	137 38	34,948 12	15,000 00	17,000 00	....	90,033 00
1893	....	18,862 50	10 50	37,927 04	15,000 00	18,000 00	....	89,800 04
1894	....	18,862 50	433 59	44,527 26	15,000 00	19,000 00	....	97,823 35
1895	....	‡19,000 00	10 50	45,301 85	15,000 00	20,000 00	....	99,312 35
1896	....	‡16,000 00	....	43,886 40	15,000 00	21,000 00	....	95,886 40
1897	....	§17,700 00	....	43,779 54	15,000 00	22,000 00	....	98,479 54
1898	....	‖17,500 00	....	47,508 28	15,000 00	23,000 00	....	103,008 28
1899	....	¶8,750 00	705 00	52,526 11	15,000 00	24,000 00	....	100,981 11
1900	....	¶72,500 00	175 00	72,298 38	15,000 00	25,000 00	....	184,973 38
1901††	....	¶72,500 00	....	63,976 79	15,000 00	25,000 00	....	176,476 79
1902	100,000 00	**1,000 00	....	64,081 81	15,000 00	25,000 00	....	205,081 81
1903	100,000 00	**1,000 00	....	65,573 90	15,000 00	25,000 00	....	206,573 90
1904	100,000 00	**1,000 00	61 19	67,312 37	15,000 00	25,000 00	....	208,373 56
1905	100,000 00	*81,000 00	....	72,035 32	15,000 00	25,000 00	....	293,035 32
1906	157,810 00	*15,000 00	....	70,286 56	15,000 00	25,000 00	....	283,096 56
1907	173,410 00	**1,000 00	....	70,155 22	23,691 60	25,000 00	....	293,256 82
1908	173,410 00	**1,000 00	....	70,385 79	23,326 10	30,000 00	....	298,121 89
1909	173,410 00	**1,000 00	....	69,527 13	26,000 00	35,000 00	....	304,937 13
1910	173,410 00	**1,000 00	....	71,109 49	28,000 00	40,000 00	....	313,519 49
1911	173,410 00	**1,000 00	....	70,304 15	30,000 00	45,000 00	....	319,714 15
1912	228,800 00	**1,000 00	....	70,265 32	30,000 00	50,000 00	....	380,065 32
1913	228,800 00	**1,000 00	....	70,289 30	30,000 00	50,000 00	....	380,089 30
1914	228,800 00	**1,000 00	....	71,324 94	30,000 00	50,000 00	....	381,124 94
1915	308,147 25	**1,000 00	....	70,385 46	30,000 00	50,000 00	$10,000 00	469,532 71
1916	560,000 00	**1,000 00	....	71,391 56	30,000 00	50,000 00	28,032 37	740,423 93
1917	560,000 00	**1,000 00	....	69,437 43	30,000 00	50,000 00	43,059 35	753,496 78
1918	560,000 00	**1,000 00	....	70,502 10	30,000 00	50,000 00	58,086 33	769,588 43
1919	560,000 00	**1,000 00	....	70,662 44	30,000 00	50,000 00	73,113 31	784,775 75
Totals	$5,021,490 85	$835,937 74	$101,723 66	$2,195,429 20	$656,017 70	$945,000 00	$212,201 36	$9,967,890 51

*Including appropriation for weather service.
†October 1, 1886, to June 30, 1887, nine months.
‡Including $5,000 for institutes and $1,000 for weather service.
‖Including $5,500 for institutes and $1,000 for weather service.
§Including $2,750 for institutes and $500 for weather service.
††To June 30.
**Weather service.
¶Including $5,500 for institutes and $1,000 for weather service.

To the State Board of Agriculture:

Early in July, 1918, a request was received from the Committee on Education and Special Training of the War Department saying that owing to the proposed establishment of a Student Army Training Corps in all the colleges throughout the land and the consequent demand for men of experience to act as Military instructors, members of our faculty who would volunteer should attend an Officer's Training School at Fort Sheridan, Ill., lasting for six weeks beginning July 10th. Dr. M. M. McCool and Professors George Gauthier, M. M. Cory and C. M. Cade volunteered for this duty and were in attendance at the school for the six weeks' course.

The entire plant of the college being made available for the training of auto mechanics and auto truck drivers—enlisted men—necessitated the erection of barracks for the accomodation of the increased numbers which the establishment of the S. A. T. C. brought about. The site selected was immediately on the east of the Horticultural building where connection with the steam system and sewerage could easily be obtained. Eight barracks and two mess halls accommodating fourteen hundred men were erected and completed just before the first of October when the College opened under the S. A. T. C. plan. Into these barracks were brought the men of Class B, those who remained under instruction for but two months and were trained in the techincal branches of auto mechanics. These were housed in the barracks and fed in the mess halls.



October first, all available places in the men's dormitories and the upper parts of the Agricultural and Engineering buildings were given over in accomodating the men of the S. A. T. C., Class A. Under Government regulations these men must all be high school graduates or have had equivalent training. Men from all over Michigan were received and on October first, with an impressive ceremony they were sworn in as joint members of the College and as soldiers in the United States Army subject to military discipline. They were clothed in U.S. uniform and received the pay of a private in the ranks.

The Navy department also established a unit for naval training consisting of fifty men. They, however, were not segregated from the S. A. T. C., but were a part of it.

All went well until the tenth of October when Influenza appeared. The characteristic symptoms of the disease were at once recognized and efforts were made by the Medical Corps to restrict the spread of the disease but without avail. As a consequence, extensive hospital space was our greatest need. The only way in which this could be provided was by moving men from the east barracks to the new gynmasium and using the barracks with cubicles as hospitals for the Influenza patients. The disease was with us from October tenth until after the armistice was signed. Deaths from the disease numbered eighteen. Aside from these many of the cases were of such a severe nature that the patients have been a long time in acquiring normal health.

Quarantine was established immediately after the Influenza showed a number of cases and the young women of the college were segregated in all class work from the young men. This quarantine was maintained for over six weeks and resulted in our being able to keep the Influenza from spreading from the army detachment to the occupants of the women's dormitories. There were only two mild cases among the young women which might have been diagnosed as Influenza but there were no deaths among the young women students throughout the balance of the prevalence of the epidemic or the rest of the college year.

I desire at this point to acknowledge gratefully the assistance rendered by both the Lansing and the East Lansing Red Cross throughout the Influenza epidemic and also the great service rendered by Miss Elizabeth Parker, College Extension Specialist in Home Nursing and Mrs. Margaret S. Holt, hostess at the Peoples Church at East Lansing. This church offered the use of their parlor as a headquarters for the friends of students suffering from Influenza, where Mrs. Holt met them and rendered every assistance.

When the first case of Influenza appeared, the feeding of the patients was a matter entrusted to the army cooks at the mess halls. As a result, the food which could be provided the invalids was of a nature suitable to a military campaign. Professors Edmonds and Garvin of the Home Economics department early recognized this difficulty and under their supervision, aid and assistance, a diet kitchen was established in the basement of the Horticultural building adjacent to the barracks. This change in the dietary gave favorable results at once.

For the next few years, no aggregation of teachers will ever gather in the United States without discussing more or less heatedly the outcome of the experiment of the establishment of the S. A. T. C. While both students and teachers endeavored to make the plan a success from an

educational standpoint as well as the standpoint of military training, owing to the multiplicity of details and the newness of the idea together with the overpowering drawback of the great Influenza epidemic, the results obtained educationally were far from satisfactory.

On the signing of the armistice November 11th, the question at once arose whether the plan of the S. A. T. C. should be continued. The matter was submitted to be voted upon at a mass meeting of the members of the corps and an overwhelming majority of the members voted adversely. This being also the outcome of similar expressions of students in other colleges, the plan was not continued beyond the close of the fall term. One of the members of the organization expressed it thus—"S. A. T. C.—Stick Around Till Christmas."

The College opened for the winter term on the pre-war basis and with a fairly large representation of young men at the opening of the term; many were back from the service in the cantonments and from time to time men wearing the service stripes from abroad dropped in so that each week showed an addition to our student body due to soldiers from the service.

The severity of the Influenza epidemic made the postponement of the winter course scheduled to begin early in November, advisable.

The Eight Weeks' courses were inaugurated as usual and at the close of those courses we made use of the now useless barracks for a display of material at our Round-up Institute which, owing to lack of space heretofore, we have never been able to do. The eight barracks, 20x120, were filled with illustrative and instructive material from the various departments of the College to which were added very interesting exhibits from the State Food and Drug Commission, the State Board of Health and the State Highway department as well as other contributors. The United States loaned us a machine gun, also a liberty motor with propeller blade which attracted much interest. As a consequence of this, our attendance during the Round-up Institute was the largest the College has ever enjoyed, estimated at between four and five thousand people. The planning and carrying out of this project should be credited largely to the efforts of Mr. Ashley M. Berridge, Director of the Winter Courses, and his assistants. Those who saw the exhibit urged upon us the necessity of making such an exhibit annually. It should be one of our future plans to provide a large and appropriate place for similar exhibits to be made annually as a feature of Round-up week.

Early in the spring term the Government began assigning to us returned wounded soldiers who under the Smith-Sears Act were eligible for technical training as a means of rehabilitation. These men have remained with us for the balance of the year and have been doing excellent work and we are confident that the efforts of the Government in this direction will warrant the outlay of money.

CHANGES IN BUILDINGS.

January first, at noon, Williams Hall was discovered to be in flames and notwithstanding the strenuous efforts of both the Lansing and the East Lansing fire departments, it was burned to the ground. This was the oldest of our present dormitories having been completed in 1868. The fire involves the loss, not only of rooms for men students but also the

matter of Club boarding facilities. Extensive improvements had just been made in the building in relation to its dining-room and kitchen facilities and the effects of the loss are serious when we consider the present and future needs of the College. It is, however, to be hoped that for the coming two years the facilities provided in the East Lansing dining halls and cafes will, together with the large facilities now existing in Wells Hall provide for our needs of the men.

(It is of interest to note that Williams Hall was occupied as a dormitory for just fifty years and was the first building heated by steam erected on the campus. At the time it came into use the college attendance for the year totaled seventy-nine—eleven seniors, thirteen juniors, twenty-seven sophomores and twenty-eight freshmen. The average age of all the classes varied from twenty to twenty-two years.)

The bell which has for the last twenty years, sounding from the tower of Williams, wakened the student to his daily duties, was lost with the building. A series of electrically controlled clocks were installed in the various buildings early in March and so far seem to fill our requirements for time service.

The small gymnasium room in the women's building having become inadequate for the needs of our increased attendance of young women and greater facilities being needed for lecture-room purposes, this room was converted into an amphitheatre lecture-room for Home Economics. To provide for the physical training of our young women, the new Gymnasium was requisitioned for their use in the forenoon for five days in the week and as a result the young women have had during the past six months the best facilities for physical training that they have ever enjoyed. A special

instructor in swimming, Miss Helen Grimes, was secured and through her efforts a large proportion of our young women are now able to swim and it will not be long before this accomplishment will be considered a neccessary adjunct to the training of every one of our young women.

RESIGNATIONS.

Professor Harry J. Eustace, who returned to take up his college work at the beginning of the present year after service under Mr. Hoover in Food Administration during the preceeding year in an important capacity, resigned as Professor of Horticulture at the close of the current year to accept a very responsible position in the advertising department of the Curtis Publishing Company of Philadelphia at a greatly increased salary. Professor Eustace will be remembered by his students both for his ability as a teacher and his preeminent social qualities.

NECROLOGY.

Henry G. Reynolds, Class of 1870, died September 5, 1918, at Pasadena, California. Mr. Reynolds served as a member of the State Board of Agriculture from 1879 to 1885. On completion of his term as a member he was elected as Secretary of the Board and served from 1885 to 1893. Mr. Reynolds' interest in the College from the time of his entrance as a Freshman never lagged in the slightest degree.

Rolla C. Carpenter, Class of 1873, died at Ithaca, N. Y., January 19, 1919. This gentleman held the Professorship of Mathematics and Engineering at this College from 1875 to 1890. From 1890 until January of the present year he was Professor of Experimental Engineering at Cornell University, retiring from active duty at that date. Professor Carpenter was one of the best known engineering instructors in the United States.

Byron D. Halsted, Class of 1871, died August 28, 1918, at New Brunswick, N. J. Professor Halsted acted as instructor immediately upon graduation, later becoming connected with the editorial staff of the American Agriculturalist and finally assuming the Professorship of Botany at Rutgers College in 1878 where he continued until the time of his death. His work as a Plant Pathologist had national recognition.

From our teaching staff two deaths due to influenza are to be recorded—Professor Rose Taylor of the Botany department died on December 6, 1918, after a week's illness.

Dr. Domina J. Lamoreaux, who graduated with the Class of 1918 and was assistant in the department of Animal Pathology, died on February 27, 1919, after an illness of but five days from influenza.

The College lost two efficient, conscientious workers.

The unclassified, employees of the College, steam fitters, electricians, mechanics and day laborers have heretofore been entirely without protection in case of sickness or accident. During the year, however, a mutual benefit association has been formed to which *all* the employees of the College are invited to membership. This is now successfully established with approximately one hundred and twenty men from the pay roll as members. I believe this is a very proper step.

The Legislature of 1919, after appointing a committee to investigate the *system of accounting and general financial administration* of the College and finding that the methods employed in the Secretary's office were entirely adequate, turned their attention to the needs of the institution and after careful investigation by the committees from both houses, unanimously passed a bill granting a total of $180,000.00 for the support of Extension work, also $560,000.00 for the expense involved in the erection of a new Library and Office building combined and also an adequate Auditorium.

On April 6th, Ex-President William Howard Taft delivered his lecture upon the League of Nations before the College in the new Gynmasium. President Taft's arrival in the city afforded an opportunity for the Legislature to invite his appearance before that body where earlier in the day he discussed the League and its underlying principles before them.

As a result of our spring Military inspection by the officer detailed from the Government, the R. O. T. C. Unit was found in such good condition, due to the untiring efforts of Major Wrightson, that M. A. C. was for the first time placed in the class of "Distinguished Colleges" by action of the War Department.

On June 10th, the College was visited by a delegation from the State of Arkansas headed by the Governor, C. H. Brough, of that state and embracing many citizens of prominence. The day was spent in the inspection of the College and its equipment which appealed so strongly to these gentlemen that they have, since their visit to us, made efforts to separate the Agricultural section from the University of Arkansas and establish it in a region which is better suited to its development than it now occupies.

Among the usual pleasant activities of Commencement an innovation was instituted consisting of a Pageant, the essential idea of which was the historical development of America from the earliest times to the present. Assistant Professor Norma Gilchrist Roseboom of the English department devised the plot of the Pageant and was assisted by the staff of the Home Economics Division. All the young women in the College participated.

Commencement day we graduated a class of one hundred and nine persons. With those receiving diplomas were members of the Senior Class who owing to the war had not completed their college work. The Baccalaureate address was delivered by Rev. William W. Atkinson of Detroit, Chaplain of the 119th Field Artillery. The Commencement address, "Yesterday and Tomorrow," was given by Dr. Robert M. Wenley of the Department of Philosophy of the University of Michigan.

In closing this chronicle I desire to express a deep feeling of gratitude for the fidelity and earnestness with which every member of the College has carried on during these most trying years.

Respectfully submitted,

FRANK S. KEDZIE,

President.

June 30, 1919.

REPORT OF THE DEAN OF AGRICULTURE.

To President F. S. Kedzie:

The work of agricultural education within the division, during the year, was seriously interfered with by the war, as nearly all students qualified for war service enlisted or were called by the draft. As the course outlined for the Students Army Training Corps, offered at the beginning of the year, did not contain any agricultural or scientific subjects closely related thereto, the agricultural course was pursued only by those unqualified for military service and those under draft age. After the signing of the armistice and the resumption of the course at the beginning of the winter term, every effort was put forth to adjust the most satisfactory classifications for those whose work had been interrupted by military service. The faculty was generous in granting substitutions for courses missed and not offered again during the year. The following table indicates the number and classification of those enrolled during the year, not including 125 who attended the first session of the summer school which began June 23rd.

SUMMARY OF AGRICULTURAL STUDENTS.

	Agriculture		Forestry
Graduate	6		0
Senior	60		2
Junior	59		5
Sophomore	57		2
Freshmen	108		0
Special	15		0
	305		9
		314	Ags.
Summer Session (1918)		47	
		361	

On account of the ravages of influenza, the opening of the short courses was deferred until January 6, 1919. These courses progressed satisfactorily with gratifying results under the capable direction of Mr. A. M. Berridge, even though the conditions were very unsettled and unusual. The following statement includes a classification of the numbers enrolled in the various courses.

SHORT COURSES.

Eight Weeks General Agriculture, First Year	66
Eight Weeks General Agriculture, Second Year	12
Sixteen Weeks General Agriculture, First Year	15
Sixteen Weeks General Agriculture, Second Year	10
Poultry Course	15
Horticultural Course	7

Special Course	10
Dairying	17
Gardening	16
Apiculture	26
Four Weeks Tractor Course	166
	360

In the Agricultural Division and Experiment Station no less than forty-six persons, mostly younger instructors and investigators, responded to the call of their country in its great crisis and rendered valuable aid in actual military service or in furnishing assistance indirectly in various ways. A word of commendation is due those who remained at home and who were called upon to increase their efforts in order to continue some of the most essential work which had been abandoned. The following list indicates the numbers of those from the various departments who engaged in military service or war work:

	Military	War Work
Dairy	5	3
Crops	5	1
Bacteriology	8	–
Horticulture	5	1
Botany	4	1
Entomology	1	..
Chemistry	3	2
Soils	1	2
Poultry	2	..
Forestry	1	1
	35	11

The following list includes the agricultural teachers and experiment station investigators, who during the past year have gone into military service or other war work:

DAIRY.

C. E. Newlander, U. S. Dairy Commission.
F. Hagadorn, U. S. Dairy Commission.
R. W. Wyant, Medical Corps.
A. C. Lytle, Army.
Paul Omans, Army.
S. J. Brownell, Army.
Herman Andrews, Officers Training Camp.
A. Ransford, Girls' Training School for Farm Work, Illinois.

CROPS.

J. F. Cox, Air Plane Supply Division, Washington, D. C.
E. E. Down, Army.
A. L. Bibbins, Army.
W. P. Murphy, Marines.
L. H. Gretton, Navy.
O. Laidlaw, Army.

BACTERIOLOGY.

Robt. Tweed, Army.
J. F. Morgan, Sanitary Corps.
C. G. Nobles, Medical Corps.
F. W. Fabian, Sanitary Corps.
I. F. Huddleson, Medical Corps.
L. H. Cooledge, Medical Corps.
L. R. Jones, Red Cross Sanitary Corps.
H. J. Stafseth, Veterinary Corps.

HORTICULTURE.

Prof. H. J. Eustace, Food Administration, Washington, D. C.
R. W. Peterson, Medical Corps.
H. Don Hootman, Army.
J. H. Carmody, Army.
E. B. More, Army.
E. C. Volz, Army.

BOTANY.

C. F. Murphy, Army.
C. W. Bennett, Army.
H. C. Young, Sanitary Corps.
Ray Nelson, Army for a while, later receiving agr. exemption.
J. H. Muncie, Bureau of Plant Industry, Washington, D. C.

ENTOMOLOGY.

P. B. Wiltberger, Medical Corps.

CHEMISTRY.

C. S. Robinson, Sanitary Corps.
E. J. Miller, Sanitary Corps.
F. F. Hebard, Naval Training School.
Percy O'Meara, Army.
T. E. Friedemann, Medical Officers Training School.

SOILS.

W. A. Laudemann, Chemical Work.
L. C. Wheeting, Army.
C. A. Hoag, Chemical Work.

POULTRY

W. E. Newlon, Army.
M. W. Dickson, Officers Training Camp.

FORESTRY.

E. C. Mandenberg, Y. M. C. A. War Work.
P. M. Hodgkins, Army.

The division is now busily engaged considering changes in courses and the addition of new ones in order to meet the demands and the great social and economic changes resulting from the war. An endeavor has been made to meet the educational needs of those returning from military service with physical disabilities as well as those desiring further education along agricultural lines resulting from changed methods of living and environmental conditions.

The members of the division are looking forward with expectancy and renewed ambitions toward the beginning of another college year when many of the disturbing factors of the horrible war shall have been left behind.

Respectfully submitted,

R. S. SHAW,
Dean of Agriculture.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

To the President:

Sir—I herewith submit the following report for the Department of Horticulture and Landscape Gardening for the year ending June 30, 1919.

From August 26, 1917, until October 3, 1918, my services were contributed by the State Board of Agriculture to the Food Administration at Washington, D. C., upon the request of Mr. Herbert C. Hoover. It was Mr. Hoover's policy of administration to ask colleges, universities, and business organizations to contribute the services of some of their men during the war period. My duties were as Associate in Charge of the Perishable Food Division.

A statement of each member of the department should be a matter of pride and record.

Mr. H. C. Moore, Extension Specialist entered the service on August 26, 1917, only a month after he entered upon his duties. He was commissioned 2nd Lieut. F. A., November 27, 1917. He was honorably discharged from the service on December 20, 1918 and at once took up his duties here.

Mr. J. H. Carmody, Extension Specialist, entered the service as a private, September 1917; was appointed Sergeant, 1st Class, June 11, 1918, and commissioned as Lieutenant, November 14, 1918, but declined the honor. He served several months in France and was honorably discharged and began his duties soon afterward.

Mr. R. W. Peterson, Assistant in the Experiment Station resigned to enter the service and has spent several months in France. At present he is stationed at Cambridge, England.

Mr. A. T. Hootman, Foreman, entered the service as a private in the Eighty-Fifth Division and has been appointed Sergeant and is now in Archangel, Russia.

It has not been the policy of the department to ask for a deferred classification for any members.

So far as possible an accurate record has been kept of every student of the department who was in the military service. Their names and class have been placed on a service roll. It contains 141 names, the only gold star name being Lieutenant Herbert J. Sheldon, of the class of 1914, who was killed in action.

Since this will be my last report, I desire to place upon record the number of students who have graduated from the Agricultural course after they have specialized in the technical work of this department during the junior and senior years.

Class of 1909........................... 6 graduates.
Class of 1910........................... 5 graduates.
Class of 1911...........................14 graduates.
Class of 1912...........................22 graduates.
Class of 1913...........................36 graduates.
Class of 1914...........................42 graduates.
Class of 1915...........................32 graduates.
Class of 1916...........................37 graduates.
Class of 1917...........................36 graduates.
Class of 1918...........................20 graduates.

Twenty-two members left the class of 1918 before graduation to enter the military service.

Several changes should be made in the Horticultural course. At present a student must elect for specialization during his senior year pomology or landscape gardening. New courses should be added that will give the opportunity to specialize during that year in vegetable growing and floriculture. Both of these industries are very large and important in the State and there is an increasing demand for opportunity to specialize along these lines.

The war conditions and small attendance of junior and senior students required modification of some features of the department work. The students' Speaking and Fruit Judging and Identification Contest was not held. For many years this contest has been fostered by the Michigan State Horticultural Society. The Annual Horticultural Fruit and Flower Show was not held nor have any of the weekly meetings of the "Hort. Club."

Upon the return to normal conditions these functions should again take their place in the horticultural instruction work.

A brief statement of the instruction work is presented in the following tables:

FALL TERM 1918.

Class.	Subject.	Instructor.	Number of Students.
Horticulture 2	Fruit Growing Required of Agr. Students.	*(This subject was ommitted from the course this fall)	
Horticulture 4	Pomology	Loree	4
Horticulture 7	Plant Breeding	Not given this term	
Horticulture 10a		Not given this term	
Horticulture 11a		Not given this term	
Horticulture 12a		Not given this term	
Horticulture 14	Elective for Women	Gunson	14

*This work was offered in the Spring and Summer Terms following, to all students returning from government service.

WINTER TERM 1919.

Class.	Subject.	Instructor.	Number of Students.
Horticulture 3	Plant Propagation Required by Agr. Students.	Loree	47
Horticulture 5	Greenhouse Industry	Halligan	16
Horticulture 8	Plant Evolution	Eustace	5
Horticulture 10b		Eustace	5
Horticulture 11b		Eustace and Loree	5
Horticulture 12b		Not given	
Short Courses	Fruit Growing	Pickford	9
First Year	Special Short Course	Halligan	15
Second Year	Special Short Course	Halligan	

SPRING TERM 1919.

Class.	Subject.	Instructor.	Number of Students.
Horticulture 6	Landscape Gardening	Halligan	16
Horticulture 9		Eustace	7
Horticulture 10c		Eustace	7
Horticulture 11c		Loree	7
Horticulture 12c		Not given	
Horticulture 13c		Not given	
Horticulture 2		Halligan	9

SUMMER TERM 1918.

Class.	Subject.	Instructor.	Number of Students.
Horticulture 3		Halligan	4
For Two Weeks	General Agricultural Horticulture	Halligan	5

A few years ago the State Board of Agriculture employed Messrs. Olmstead Brothers of Brookline, Massachusetts, Landscape Architects, to make a plan with recommendations for the future development of the campus, largely dealing with the location for future buildings. The gymnasium is located where this plan called for. The recent destruction of College Hall and Williams Hall and the legislative appropriation for a new library and auditorium have made it seem desirable to ask Mr. Olmstead to visit the campus and study the situation first hand and make suggestions and recommendations for the location of these new buildings. Mr. Olmstead visited here on June 3rd and will make a report in due time. It seems highly desirable to follow the suggestions of this firm as they have made a life-long study of college campuses and many city parks and by reason of this have very much more extensive information on the desirability of locating important buildings than local authorities. They have proven themselves to be farsighted and make plans for many years in advance. Then, too, the recommendations are not based upon any local opinions which must be tempered with personal preferences and opinions.

The Department staff has been as follows:
Harry J. Eustace, Professor of Horticulture.
Charles P. Halligan, Professor of Landscape Gardening.
Thomas Gunson, Assistant Professor of Horticulture; Superintendent of Grounds.
R. E. Loree, Assistant Professor of Horticulture.

Respectively submitted,
H. J. EUSTACE,
Professor of Horticulture.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY.

To the President of the Michigan Agricultural College.

Sir:—Any departmental report for the academic year, July 1, 1918 to June 30, 1919, must of necessity take cognizance of the unusual conditions occasioned by the war. The story of the year's activities, therefore, is the history of retrenchments and adaptions rather than the usual narrative of increased student registration and departmental expansion.

From the beginning of the training of the Motor Transport Units to the end of the Students' Army Training Corps the responsibility for providing a suitable milk supply for the detachments was placed upon the Dairy Department. Inasmuch as the demands were rather erratic, it was necessary for the department to secure suitable milk supplies and see that these were properly clarified and pasteurized and delivered to the mess halls.

With the opening of the fall term about 3,000 pounds of milk were supplied daily for the soldiers in training. This was the approximate equivalent of two quarts per day for each individual in training. By careful attention to the details surrounding the milk supply the training units were adequately protected from milk-born diseases.

THE DEPARTMENTAL STAFF.

The department numbered ten men on its teaching and investigational staff at the beginning of the war. This number was reduced to four during the fall of 1918 and some of these were prepared to leave for military service at any time. The securing of proper help to care for the dairy herd and to conduct the necessary operations in dairy manufacture and dairy distribution became a very serious problem and at times it was necessary for the instructors to lend a hand in order to make out. We are pleased to report, however, that the close of the fiscal year sees us with the following personnel in the department.

A. C. Anderson, Professor of Dairy Husbandry.
H. W. Newhall, Associate Professor of Dairy Husbandry.
J. E. Burnett, Assistant Professor of Dairy Husbandry.
F. T. Riddell, Investigator in Dairy Production.
Stanley J. Brownell, Investigator in Market Milk Distribution,
R. W. Wyant, Instructor in Dairy Manufactures.

INSTRUCTION.

Beginning with the winter term the regular courses in dairy manufacture and the short courses for dairy manufacture students were given on the regular schedule. The numbers taking these courses, however, were less than in former years.

Every opportunity has been given returning students throughout the year by repeating courses for the convenience of men who have found it necessary to take these required courses in order to complete their collegiate work at the desired time. While these classes have been small, we must especially commend the excellent spirit which the students have shown and express our appreciation of the rather high degree of accomplishment which they have attained under reconstruction conditions.

INVESTIGATION.

During the year further investigations of Mr. F. T. Riddell in the cost of market milk production have been completed in the Howell and Webberville districts and similar work has been taken up in Macomb, and Wayne and Monroe Counties. The cost work of Mr. Riddell has been of inestimable value in giving stability to milk prices and in creating a better economic atmosphere for the dairy farmer.

In February, 1919, Mr. Stanley J. Brownell was released from military service and immediately resumed work with the department as Investigator in Market Milk Distribution. He has gotten well started on his project.

DAIRY EXTENSION.

Throughout the year Mr. J. A. Waldron has continued to serve as Extension Specialist in Dairy Products and Mr. O. T. Goodwin as Extension Specialist in Dairy Manufactures. Both have rendered very valuable service. A detailed statement of their activities will, of necessity, appear in the report of the Director of Extension.

ADVANCED REGISTRY TESTING.

The work of Advanced Registry testing continued throughout the war with only a slight decrease. The work of Prof. Burnett in securing suitable help in caring for these tests was rendered doubly hard on account of the labor shortage, but by dint of extraordinary effort all the requests for supervisors were taken care of.

Requests for the more unusual class of extension service for the dairy industry have been frequent during the year. Scarcely a week has passed in which the services of the writer have not been requisitioned to take care of these less routine conditions. Among these have been a number of conferences in different cities at which information has been given to city commissioners, boards of commerce, citizens' committees, milk producers and distributors, and others relative to the problems of market milk production and distribution.

During the year the writer has continued to serve as a member of the Detroit Milk Commission.

In closing this report we must express our most sincere appreciation for the degree of cooperation from the members of the department and all others with whom we are associated in collegiate work.

Respectfully submitted,
A. C. ANDERSON,
Professor of Dairy Husbandry.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF FARM CROPS.

President F. S. Kedzie, East Lansing, Mich.

Dear Sir—I herewith present a brief report of the work of the Farm Crops Department during the period beginning July 1, 1918, and ending June 30, 1919.

The unusual conditions prevailing during the past year influenced the instructional work of the Farm Crops Department to a marked extent. The opening of the fall term came at a time when the war was at its heighth. Our fall classes were greatly reduced in numbers, but the signing of the armistice and the early release of men changed the situation rapidly.

In order to provide sleeping quarters for the S. A. T. C. men quartered at the College during the fall term, the instructional equipment was removed from our large laboratories, numbers 310 and 311, and these rooms were turned over to the Military Department.

Farm Crops II was not given in the spring but was given during the first term of summer in order to arrange a satisfactory schedule for returning soldiers. The appearance of several special students who had received wounds while in service, and were being educated at government expense, necessitated a slight modification to accomodate them in our spring courses.

The attendance during the summer school of 1919 was much larger than ever before, the majority of the students being returned soldiers who desire to accomplish their graduation requirements at the earliest opportunity.

Under the direction of Mr. J. R. Duncan the crops materials for exhibit and classroom purposes was greatly increased in quantity and improved in quality.

The following members of the department of the instructional staff were absent on leave for army service:

A. L. Bibbins, Corporal, M. S. T. 409, M. T. C. 375, overseas service June 30, 1918 to June 30, 1919; Instructor in Farm Crops.

E. E. Down, Corporal (Co. H.) 58th Inf., overseas service, June 30, 1918 to June 30, 1919; Instructor in Farm Crops.

J. F. Cox, 1st Lieutenant, Air Service, A. P. August 25, 1918 to January 1, 1919; Professor of Farm Crops.

On the return of Mr. Bibbins and Mr. Down, the department will be better able to meet the increasing duties accompanying the rapid return of students.

A brief summary of courses, number of students enrolled, and instructors in charge is herewith given.

Farm Crops I, Cereal Crops, Freshman Course, Winter Term, 93 students.
J. F. Cox, Professor of Farm Crops.

Farm Crops II, Forage Crops, Sophomore Course, Spring Term, not offered until summer,
C. R. Megee, Assistant Professor of Farm Crops.

Farm Crops III, Grain Judging, Senior Course, Fall Term, 7 students.
C. R. Megee, Assistant Professor of Farm Crops,
Mr. J. R. Duncan.

Farm Crops IV, Special Michigan Crops, Senior Course, Spring Term, 38 students,
J. F. Cox, Professor of Farm Crops,
C. R. Megee, Assistant Professor of Farm Crops,
Mr. J. R. Duncan.

Farm Crops V, Crop Improvement, Senior Course, Winter Term, 22 students,
F. A. Spragg,
Graduate Assistant Foster Rudolph.

Graduate Assistants

Eight and sixteen weeks Short Course (combined) 81 students,
C. R. Megee, Assistant Professor of Farm Crops.

Summer Session, 1919.

Farm Crops II, Forage Crops 8 students,
C. R. Megee, Assistant Professor of Farm Crops.

Farm Crops III, Grain Judging, 10 *students,*
J. F. Cox, Professor of Farm Crops,
Mr. J. R. Duncan.

Crops and Soils, first half 5 students
C. R. Megee, Assistant Professor of Farm Crops.

Short Course for Ministers, 9 students
J. F. Cox, Professor of Farm Crops.

I take pleasure in reporting the hearty cooperation on the part of all members of the department.

Yours, truly,
J. F. COX,
Professor of Farm Crops.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF SOILS.

President F. S. Kedzie:

Again I am able to report progress in all lines we have under way. Although the demands have been unusual and great and the duties arduous, we consider the ensuing year to have been the most successful we have experienced. It is doubtless true that there never has been greater interest manifested in better soil management by the people as a whole than in the recent past and at present. As a result of observations, correspondence and interviews with farmers I am forced to conclude that there is less known concerning the properties of and the fundamental principles underlying good soil management than any other phase of agriculture. Many agricultural workers in addition to the farmers as a whole, have taken it for granted that this is a relatively simple matter and gone on the assumption that we are dealing with an inert material or simply "dirt", if you please. Now as a matter of fact this is far from the truth and we have to deal with substances that are most complex and the sooner we come to look upon the soil as a whole, as being made up of many individuals each having to a greater or less extent an individuality of its own, and recognize the tremendous importance of permanent systems of soil fertility to this commonwealth and the nation, the less short sighted we shall be.

I look upon the state as a huge school. There are many who could well be considered, so far as their knowledge of the subject is concerned, to be in the lower grades, while others are more advanced. It will always be thus. This means that the work will never be completed and thr possibilities for constructive work unlimited. The university professor o

others who minimize agricultural education by writing and speaking to the effect that we know how to farm is ignorant of the broad relationships that exist. In view of these conditions it is doubtless true that the extension activities along soils lines should be carefully, but greatly increased.

In order to provide constantly information to be extended it is essential that the experimental and research work be supported both morally and financially. In this connection I desire to call your attention to that which has been accomplished by the staff with a relatively small amount of funds at its disposal.

The educational phases at the College have been improved. Much remains to be accomplished and it is proposed to revamp certain of the courses that are offered.

We, as members of the Soils Section, express our gratitude to you for the interest taken in our work.

Respectfully submitted,
M. M. McCOOL.
Professor of Soils.

East Lansing, June 30, 1919.

Lawrence Clifford Wheeting.

Drafted at Mason, Mich., Nov. 21, 1917 and assigned to Co. C, 338th Inf., 85th Div., Camp Custer, Michigan. Entered 3rd O. T. S. January 5, 1918; completed April 19, 1918 and returned to Co. C, 338th Inf. as Sergeant. Transferred to Inf. Repl. Camp, Camp Lee, Va., May 27, 1919. Commissioned 2nd Lieut. of Inf. June 1, 1918. Transferred to 160 Depot Brigade, Camp Custer, July 16, 1918 and attached to Co. C, 1st Dev. Bn. Transferred to 32nd Co. 8th Bn. August 6, 1918. Transferred to 10th Inf. 14th Div., August 22, 1918 and assigned to Co. H, 2nd Bn. Discharged January 29, 1919, as Second Lieutenant, 10th Inf.

George John Bouyoucos.

Red Cross Agricultural Commission—Balkan States—October 1918, October 1919.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

President F. S. Kedzie, East Lansing, Mich.

Dear Sir—*I have the honor to submit the following report of the* Department of Animal Husbandry for the year ending June 30, 1919.

The instruction work during the past year has been conducted as outlined in the College catalog. The work of the staff and the enrollment in various courses is summarized in the accompanying table.

It is a pleasure to report continued progress in the improvement of the herds and flocks. The Hereford herd of fourteen females are all descendants of one cow purchased in 1910 at a cost of $150. There are, at the present time, eight daughters and six grand-daughters of this cow in the herd, all of them showing a remarkable uniformity of type. The Aberdeen Angus herd consists of eight females, most of them descendants of one cow purchased in 1910 at a cost of $150. During the past year a Hereford sire was purchased from J. E. Thompson of Martinsville, Ill., and a Shorthorn sire from J. F. Prather of Williamsville, Ill.

While we have excellent foundation herd of Shorthorns, Herefords and Aberdeen Angus, the limited area of land available for the livestock equipment renders it difficult to retain many of the younger animals and increase the herds as much as would seem desirable. The scarcity of pasture the last two years has made the maintainance of the herds and flocks a difficult problem and I would earnestly recommend that the College obtain more land as soon as conditions will permit.

Term.	Subject.	Teacher.	Hours per week.	Students enrolled.
Summer School	Animal Husbandry 1	W. E. J. Edwards	10	7
Summer School	Animal Husbandry 2	W. E. J. Edwards	10	5
Summer School	Animal Husbandry 4	G. A. Brown	10	6
Fall Term	Animal Husbandry 1	W. E. J. Edwards	6	33
Fall Term	Animal Husbandry 2	W. E. J. Edwards	6	29
Fall Term	Animal Husbandry 5	G. A. Brown	8	7
Winter Term	Animal Husbandry 4	G. A. Brown	5	42
Winter Term	Animal Husbandry 6	G. A. Brown	8	35
Short Courses	Animal Feeding	W. E. J. Edwards	5	70
Short Courses	Types of Livestock	W. E. J. Edwards	10	68
Short Courses	Breeds of Livestock	W. E. J. Edwards	8	23
Short Courses	Judging Livestock	R. L. Mackie	6	9
Spring Term	Animal Husbandry 7	G. A. Brown	8	29

Both Mr. Edwards as instructor and Mr. Mackie in charge of livestock have rendered loyal and efficient service. The teaching work for the past year has been more than three men should be required to handle and with a return to a normal enrollment next year more help will be needed.

Respectfully yours,
GEORGE A. BROWN,
Professor of Animal Husbandry.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY.

President F. S. Kedzie, College.

Dear President Kedzie—I have the honor to submit the following report of the Department of Poultry Husbandry for the year ending June 30, 1919.

BUILDINGS.

We are occupying eighteen buildings, one house 18 feet by 184 feet, one house 16 feet by 84 feet. Three houses each 16 feet by 24 feet, three colony houses 6 feet by 8 feet, seven portable colony houses 10 feet by 12 feet, one open front house 20 feet by 20 feet, 1 open front house 14 feet by 28 feet and one house 10 feet by 14 feet.

No construction work has been done upon the poultry plant during the year, owing to war conditions.

EQUIPMENT.

The department has operated seventeen incubators. One 2400 egg size, hot water heat. Two 200 egg size, three 150 egg size and eleven 70 egg size. Total incubator capacity 3, 020 eggs. Students have received instruction in handling both methods of heating incubators—hot air and water.

Brooding capacity has been enlarged to 6,000 chicks. The colony stove plan of brooding has been employed and instructions in handling same have been given.

Breeds of fowls for demontsration purposes are kept as follows: Plymouth Rocks, all varieties, viz., Barred, White, Buff, Silver, Penciled, Partridge, and Columbian.

Wyandottes—Four varieties, viz., White, Buff, Columbian, and Silver. Domniques, Langshans, Single Comb Black Minorcas, Buff Orpingtons, Dark Cornish, Speckled Sussex, W. C. Black Polish, S. S. Hamburgs, Houdans, Silver Campines, Sultans, Black Cochins and Partridge Cochins, Rhode Island Reds, both varieties, viz., Single Comb and Rose Comb. Leghorns, five varieties, S. C. Brown, Rose Comb Brown, S. C. White, S. C. Buff and Silver.

Ducks, four varieties, viz., Pekin, Muscovy, Rouen and Call.

Geese, five varieties, viz., Toulose, Emden, White Chinese and Brown Chinese.

About 1,100 head of stock were wintered on the plant. Nearly 2,400 head of young stock are being reared this summer.

Owing to war conditions no classes were formed in poultry last fall. A summer term with an enrollment of 12 was taught. A short course with an enrollment of 15 was given during the winter.

Investigational and experimental work is being carried forward and standardizing of poultry pedigreeing has been begun.

As suggested by a letter from you on June 17th, I am submitting the military record of Mr. Dickson from our department.

Matthew Ellis Dickson entered the service on July 27, 1918 at Camp Custer. On September 1, 1918 he was transferred to Camp Zachary Taylor Louisville, Ky., to the Field Artillery Officers Training School, from which he received his commission as Second Lieutenant in the Field Artillery U. S. A. on December 18, 1918. He was discharged on the same day but remains in the Reserves until December 18, 1923.

The Poultry Department carried forward a series of poultry schools each covering a period of from three to six days. Work was done in conjunction with the Farm Bureau and poultry organizations in a number of counties. The work had in mind three things. First, to widen the scope of poultry work. Second, to demonstrate the power to so cull the flock that it can be made to pay a profit upon the average farm. Third, to demonstrate that the fowls of the future will be more uniform in shape and color and possess a larger egg record and a better quality of meat producing power than in the past.

Free admission to these schools was given in all cases except in three of the larger cities, namely: Detroit, Battle Creek and Grand Rapids. These schools were met with marked interest. Three sessions were held each day from 10 to 12, from 3 to 5 and 8 to 10:30 p. m.

The Federal government cooperated with the department in furnishing moving pictures which were shown every night during the school. School children were admitted on special nights.

Schools were held in Marlette, Holland, Flint, Battle Creek, Chicago, Grand Rapids, Muskegon, Detroit, East Lansing, Chelsea, Dublin and Hartford with an enrollment of 10,200 based directly upon an aggregate attendance and included in the majority of cases students that attended every session. People who attended the sessions and who did not enroll as students the numbers of which were conservative estimates taken from reception committees reports showed an attendance of 36,300.

The above work was considered by the Department of Poultry Husbandry as a part of the war work of activities of the department.

Respectfully submitted,
C. H. BURGESS,
Professor of Poultry Husbandry.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF FARM MECHANICS.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the report of the Department of Farm Mechanics for the year 1918-1919.

WAR WORK.

Attention for the greater part of the year 1918 was focused on the preparation of soldiers in the United States Army Truck and Tractor School for a part in the conflict. The tractor and gas engine work, for which this department assumed responsibility, was carried on in addition to the regular correspondence and assistance which was given directly to the farmer.

In the matter of the loan of equipment for carrying on this work, we are indebted to the generous cooperation of the manufacturers of gas engines and tractors whose assistance enabled us to present this work in a credible way. The eagerness of the soldiers to learn and the willingness of the instructors to give made this work a real satisfaction.

Through this school, the department has left for use three farm tractors, one of which was given for this purpose.

I wish to express appreciation of the cooperation which I have had from those associated in this work, both in the Army School and in the regular work.

As a part of the Army School work, I gave the lectures on tractors and gas engines. Mr. O. E. Robey dropped the Extension work in Household Engineering at the beginning of the war and took up Drainage Extension work in its place. It was felt that Drainage would be of more immediate importance in producing food than the work in buildings, conveniences, and sewage disposal.

Wilson Duncon, Instructor in Blacksmithing, had charge of the shop work in the Army Horseshoeing School.

Samuel Toms, whose resignation was accepted for May 1, 1919, assisted in the Army School work as tool-keeper and caretaker of the laboratory.

The School of Horseshoeing, which was given in cooperation with the Veterinary Division and through the cooperation of the State Constabulary

in furnishing horses, was also an important part of our instructional war work, though but one term of eight weeks work was presented to twenty-five men. Some interesting facts were brought out in this course, showing the value of intense application to one line of work. While it could not be claimed that expert shoers were developed, it was proven that a good working knowledge and some skill in this work could be acquired in this time.

The necessity for increased use of machinery from lack of labor during the war, and the interest in developments and construction since its close has had a marked effect upon correspondence and in requests for advice along farm mechanics lines. It is my hope that this work can be amplified, especially on the side of preparation and investigation to meet the growth of interest manifested in the State.

INSTRUCTION.

Beginning in January 1919, instruction was given in Power Machinery to twenty-eight regular students and to thirty-nine Short Course men.

Wood and Forge work were each given to about seventy-five Short Course men.

In addition, two one months courses in Trucks and Tractors were given to a total of one hundred and seventy-five men. For the work in trucks, shop work, ignition and truck engines, we are indebted to the Engineering Division for their cooperation. The cooperation of manufacturers and distributors gave us the use of a dozen different tractors for study and practice.

In the spring term, the course in Farm Machinery was presented to eighteen men and the course in Farm Drainage to nine.

INVESTIGATION.

Little opportunity has been afforded either in time or funds, for investigational work for the past year. A brief inspection of twenty-five septic tanks was made in January and February to determine their condition in mid-winter. This summer, records are being kept of tractors on the College farm.

Drainage, which is being done under the extension specialist affords, an excellent opportunity for further study.

EXTENSION.

The work of the past year of Mr. O. E. Robey, who has devoted his time largely to Drainage, is commendable. This work taken up as a war measure has opened up a field for which a real and pressing need is felt. A large number of farms have been inspected and advice and cooperation given.

Under the plan being tried this season, a traction ditcher has been engaged to drain demonstration plots in St. Clair county. A successful completion of the work planned for the season will place a twenty acre field or larger under the observation of nearly every farmer in the county. Great interest is exhibited and groups have been organized to buy ditchers and tile. Several hundreds of dollars have been saved the farmer in the purchase of tile at dealers prices, which plan has been in operation but a short time.

Respectfully submitted,
H. H. MUSSELMAN,
Professor of Farm Mechanics.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF FORESTRY.

The President, Michigan Agricultural College.

Sir—I have the honor to submit the following report for the Department of Forestry for the year ending June 30, 1919.

The work of instruction, while following the sources described in the catalog as closely as possible, was light in the fall term owing to the fact that there were few regular students. Conditions being more normal in the winter term it became necessary to give certain fall term courses which were pre-requisite to the winter term work and for this reason some courses were given twice during the year. The teaching work for the year was as follows:

	Number of Classes	Number of Students
A. K. Chittenden	9	128
F. H. Sanford	8	36

During the fall term Professor Sanford assisted in gymnasium work. The courses in Forest Policy and Forest Products have been changed so as to have as great a bearing on reconstruction problems as possible and certain other courses were slightly modified during the year for the same reason.

The war apparently stimulated interest in forest planting, the demand for small trees this spring being unusually large. The department has endeavored to secure the reforestation of areas of valuable timber that were cut for war-time purposes and has particularly urged the planting of black walnut in the southern part of the state as this timber was heavily drawn on for gunstocks and airplane construction. Planting stock amounting to 178,000 trees was shipped from the forest nursery during the year. The nursery is in excellent condition, last year's seed bed being particularly good. The Christmas tree plantation which was established several years ago was completely cut over this year. Thinnings had been made in it for the last three years and it proved remarkably successful. A new plantation was set out this spring. Some underplanting was also done in the older plantations in the nursery. These plantations are becoming very valuable for instructional as well as experimental work.

The sugar bush in the river woodlot was operated as usual, the demand for syrup being again heavy. A gasoline drag saw was obtained for use in cutting cordwood and has resulted in a saving of labor.

The experimental work in the sugar bush was continued. This work involves a study of sap flow and will of necessity cover several years, but data so far collected shows more uniformity than had been expected. It is the intention to publish the results from year to year as they become available.

The sand dune fixation work was also continued. A large number of trees were planted on demonstration areas near Muskegon and Holland. The interest taken in this work by the community was shown by the number of farmers who came out to assist in the planting. The department is keeping in close touch with demonstration areas already established and is studying the growth and behavior of the trees under these trying conditions.

Experimental work was also done on the rooting of cedar cutting

The Department of Horticulture loaned us the use of one of their greenhouses for the purpose and the cuttings were furnished by a nursery company.

A growth study of forest plantations was begun, including costs and returns. It is contemplated to extend this work to nut tree plantations.

During the fall term the extension work was carried on by the department staff. Mr. E. C. Mandenberg, Extension Specialist in Forestry, returned to the College on January 1. The second annual meeting of the Michigan Maple Syrup Makers' Association was held at the College during Farmers' Week and was well attended. The department has through the courtesy of the Barrett Company, obtained the use of a portable plant for the preservative treatment of fence posts which will be loaned to farmers without charge other than transportation.

With regard to work contributory to the war activities program I would say that I served as a member of the War Committee of the Society of American Foresters, as Listing Officer for the 20th Engineers (Forest), and as Chairman of the Wood Fuel Committee under the State Fuel Administration. Professor Sanford also served as a member of the latter committee. The department collected a large amount of data on the forest resources of the State, which data was made available for the War Department. Many of the graduates of the department who were unqualified for active military service were appointed timber or dry kiln inspectors in the Aircraft Production Division of the War Department and rendered efficient service.

The chief needs of the department are an experimental dry kiln for instructional work and more space for the wood technology laboratory. At the present time some of our equipment has to be stored in the attic for lack of space in the laboratory.

Respectfully submitted,
A. K. CHITTENDEN,
Professor of Forestry.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF AGRICULTURAL EDUCATION.

To the President and Members of the State Board of Agriculture:

I have the honor to submit the following as an annual report of my department for the current year.

(a) Courses in Education for women. During the fall term we enrolled seventy women in Education. During the winter seventy-seven and during the spring term sixty-three. These classes were made up of juniors and seniors. The work was arranged in two sections. At the close of the college year fifty-eight seniors had completed the work in Education and were recommended by the faculty to the State Board of Education for teachers' licenses, granted under the general law. Of this number fifty-one had taken the special work in Education in the home economics department, together with practice teaching, and were entitled to a special home economics certificate, which would authorize them to teach the subject in Smith-Hughes schools. These certificates have been granted by the Superintendent of Public Instruction.

(b) Education for men. During the fall term on account of war conditions, there were no senior students in the subject of Education. Dur-

ing the winter term we enrolled forty-two and during the spring term, by permission of the faculty, we gave two courses in education for men. Education 4 to twenty-six seniors and Education 6 to thirty-eight juniors and seniors. This was a special arrangement in order to enable men who had been in military service to complete their courses and be graduated. Of the seniors, twenty completed the work in Education, together with the four year college course and were entitled to a state teachers license and on recommendation of the faculty these certificates had been granted by the State Board of Education.

(c) The Practice School. Last year arrangement was made between the State Board of Agriculture and the Board of Education of East Lansing for the establishment of teacher training courses in agriculture and in home economics in the East Lansing High School. The subjects offered were elective to high school students and for the agriculture about thirty students selected the work, thus affording four good classes for practice teaching. About forty-five young women elected the course in home economics, giving good strong classes for the practice teaching in that subject.

On account of war conditions we had no men for practice teaching during the fall term and the early part of the winter term. By that time, however, we had enough returned soldiers to organize the class in practice teaching.

In the matter of critic teacher, Mr. Grover had conducted the regular courses for the high school students. Miss Frazer organized the practice teaching immediately upon the opening of the school year and during the year has given special training to fifty-one young women of our senior class. All of this work was conducted under the general supervision of the State Board of Control for Vocational Education in accordance with Federal and State laws, for the purpose of training young men and women for vocational teaching. We have prepared many more in both agriculture and home economics than will be needed at present but many of these will be utilized in other states.

(d) During the year courses in agriculture have been taught under the provision of the Smith-Hughes Law in forty-six high schools of the State. In all but three the graduates of this collage are in charge of the work. Ten new schools have already made application to the State Board of Control for the establishment of the agricultural course, beginning in September.

There are ten schools in the State where home economics is taught under the provision of the Smith-Hughes Law. In five of these the instructors are graduates of this institution.

(e) The Critic Teacher. The direction of practice teaching in agriculture is in charge of Mr. E. Lynn Grover and his work has been entirely satisfactory to the public school officials so far as the management of the children is concerned and entirely satisfactory to the college authorities. I consider him one of the most proficient directors of agricultural education in the middle west; in fact, I question whether he has a superior in any of the states.

Miss Elizabeth Frazer, the critic teacher in home economics, has made an enviable reputation for herself through her proficient work in directing the practice teaching of the young women. Our senior students without exception, were pleased and satisfied with their training under her

direction. The College is to be congratulated on having been able to secure from its own graduates two such eminently well prepared people for this new but important field of college service.

(f) Teacher Training. By action of your honorable body I was made director of teacher training for both men and women after the passage of the Federal law, providing grants of money to educational institutions in which vocational teacher training was given. As director of teacher training it has been my duty to supervise the work of teacher training in agriculture and home economics in order that I might wisely guide young men and women students who were prepared to teach. It has also been my duty to give to them technical courses in education which I have done to the best of my ability. By request of the State Board for Vocational Education I was permitted to give a portion of my time for the benefit of that Board in directing and developing vocational education in the State. During the past year I have given approximately one-fourth of my time to this work. In that capacity it has been my duty to organize the vocational courses to be given in the public schools and for this I prepared a plan for vocational education in Michigan, which was approved by the State Board of Control and by the Federal Board.

I have also prepared a number of bulletins, giving explicit instruction concerning the development of the different types of vocational education.

I have also acted as advisor to the state supervisors of the several types of vocational education. While serving in this dual capacity of acting director of vocational education for the State and as director of teacher training for the College, I have endeavored to promote the best types of education in both lines.

Respectfully submitted,
WALTER H. FRENCH,
Professor of Agricultural Education.

East Lansing, June 30, 1919.

REPORT OF THE DEAN OF ENGINEERING.

Dr. F. S. Kedzie, President, Michigan Agricultural College.

My dear Mr. President—I have the honor to present my twelfth annual report as Dean of Engineering for the fiscal year ending June 30, 1919.

A. *Personnel of the Division of Engineering.*

1. G. W. Bissell, M. E. Dean of Engineering.
   Miss McCann, Clerk.

2. *Civil Engineering.*

   H. K. Vedder, C. E. Professor.
   C. A. Melick, D. C. E. Associate Professor.
   R. G. Saxton, C. E. Assistant Professor.
   C. M. Cade, B. S., C. E. Assistant Professor.
   W. W. Hitchcock, B. S., C. E. Instructor.
   B. K. Philp, C. E. Instructor.
   Miss Colvin, Clerk.

3. *Drawing and Design.*

R. K. Steward, B. S., C. E. Professor.
C. Newman, Associate Professor.
L. N. Field, B. M. E. Associate Professor.
J. W. Steward, B. M. E. Assistant Professor.
A. G. Scheele, A. M. Assistant Professor.
Miss C. L. Holt, Instructor.
E. H. Stewart, B. S. in M. E. Instructor.
Miss E. Butler, Instructor.
J. Rising, M. E. Instructor.
Miss Matthews, Clerk.

4. *Electrical Engineering.*

A. R. Sawyer, B. S., E. E. Professor.
M. M. Cory, E. E. Associate Professor.
P. G. Andres, B. S. Assistant Professor.
Miss Colvin, Clerk.

5. *Mechanical Engineering.*

(a) J. A. Polson, M. E. Professor.
(b) H. B. Dirks, B. S., M. E. Professor.
W. E. Reuling, B. S. in M. E. Assistant Professor.
A. P. Krentel, Instructor.
J. A. Eicher, Instructor.
G. C. Wright, B. S., in M. E. Instructor.
W. G. Hildorf, B. S. Instructor.
G. J. Posthumus, Instructor.
R. G. Bigelow, B. S. Instructor.
A. Watt, Instructor.
E. C. Crawford, Assistant.
C. N. Rix, Assistant.
Miss Houston, Clerk.

The above named, 35 persons, were in active service during the entire year with the following exceptions:

J. A. Polson, resigned, effective April 1.
H. B. Dirks, appointed, effective May 1.
J. Rising, appointed, effective Jan. 1.

Of the entire staff, 26 persons had offices in the R. E. Olds Hall, which furnished office space also for the Department of Mathematics, 7 persons, making a total number of 33 persons stationed in this building.

During the year, Messrs. Iddles and Messenger, absent on leave in army service, have resigned their positions with the College. Mr. Chapin, absent on leave and recently discharged from army service, has expressed a wish to return and will do so. Mr. Ward, absent on leave in army service has not yet been discharged.

Mr. Bigelow has decided not to continue his connection with the College.

In the resignation of Mr. Polson, the College has lost a very valuable and estimable man. Appointed as instructor in 1906, he won his way to the headship of his department in 1917. As administrator, teacher and engineer he was a credit to himself and to the Division.

Mr. Polson is now mechanical engineer for the Milwaukee Stamping Company, at a salary and with prospects beyond those which existed for him here or anywhere else in teaching work.

Several candidates for his position were considered, corresponded with and interviewed and from them Mr. H. B. Dirks of Princeton University was appointed. Mr. Dirks is a graduate of the University of Illinois, in which institution and at Princeton he acquired several years of teaching and investigational experience. In addition to his work as a teacher, Mr. Dirks has had five years experience in practical manufacturing work. I believe him to be very well qualified for his position here.

B. *Salaries.*

Departmental reports submitted to you have recommended much needed increases in salaries, and I am pleased to feel that it is the intention of yourself and the Board to grant the advances asked so far as the resources of the College will permit.

Otherwise, high living costs, the demands of the industries and competition of other schools will cause vacancies which will be difficult to fill.

C. *Student Enrollment.*

	Fresh.	Soph.	Jun.	Sen.	Total	Graduates
1915–16.....	131	88	83	71	373	66
1916–17.....	127	88	64	68	347	65
1917–18.....	123	78	40	37	278	29
1918–19.....	132	57	32	23	244	23

The above figures give the enrollment in engineering from the year of the fire to the present and show the effect of the war.

I have made the following estimate of the enrollment for 1919-20:

	Chem.	Civil	Elec.	Mechan.	
Freshmen....					150
Sophomores..	14	40	22	32	108
Juniors......	6	14	12	17	49
Seniors......	7	6	6	8	27
Returned from war service..................					50
Total..................................					384

D. *Course of Study.*

A revision of the course of study is in progress. The changes proposed contemplate:

1. Four (4) credits per term of specialization in the sophomore year. Hitherto the course has been uniform from the first two years.
2. Deferment of the economics courses to the last two years.
3. Conversion of shop course from the purely manual to the laboratory type.
4. Additional group options in the Senior year.

The freshman year of the new course will be effective in 1919-20, and has been duly announced in the catalog.

E. *Buildings.*

The new buildings are very satisfactory as to space and appointments

F. *Equipment.*

The several departments have made considerable progress towards replacement of equipment destroyed by fire in 1916, but much remains to be done as rapidly as funds and prices will justify.

G. *War Service.*

M. A. C. co-operated with the government of the United States in its work of prosecuting the Great War by:

(a) Releasing members of the College staff for war service with various branches of the Federal government.

(b) By its hundreds of students and former students who served in militant and civilian capacities.

(c) By its part in the Students' Army Training Corps (S. A. T. C) Sections A and B.

(d) By radio code courses to our students awaiting call to service.

(e) By extension work in food production and conservation, and in fuel conservation.

1. *S. A. T. C. Section A.* This work was planned for men of college caliber, the intention being to utilize the colleges as preliminary training or selective camps for officers training camps and schools for non-commissioned officers.

Eight hundred and sixty students were duly enlisted in Section A of the S. A. T. C., fifty of these being a naval unit.

Inherent difficulties in the system, influenza and the armistice combined to terminate this work by the end of the fall term, 1918.

2. *S. A. T. C. Section B.* This work contemplated vocational training for soldiers selected for their probable aptitude for the respective vocations.

On April 22, 1918, acting on a preliminary understanding with the Committee on Education and Special Training of the War Department, verified by formal contract on May 3, active preparations were begun for receiving and training as auto-mechanics a detachment of 500 drafted men for a period of two months beginning May 15th. The men came from Wisconsin on the 16th and numbered 520. Instruction began on the 20th with a complete equipment including 10 Class B army trucks and a teaching and administrative *personnel* of about 60 persons. It is a matter of pride that the organization worked smoothly and efficiently from the start, both within its own interests and in those matters requiring cooperation with the military authorities.

The teaching and administrative staff was recruited from the regular force of the engineering and farm mechanics departments, from our own engineering students under draft age, from auto-schools, from garages and shops, and after starting, from the ranks of the soldiers themselves.

Illustrative, demonstrative and working equipment was loaned by the government, purchased, loaned by auto and accessory companies or constructed as could be done the quickest and the best.

The instruction scheme divided the men into 8 platoons of 8 squads each and the assigning of each platoon to one-week periods of instruction in eight sub-divisions of the work as follows:

1. General chassis repair.
2. Chassis units repair, except engine and electrical units.
3. Engine repair.

4. Electrical ignition, lighting and starting.
5. Carburetor trouble and block running.
6. Road driving and trouble.
7. Forge work.
8. Tractors and stationary gas engines.

The first detachment left on July 14th and was distributed as follows: 250 to Camp Hancock, 162 to Camp Jackson, 27 to Raritan Arsenal, 33 were retained as instructors and clerks, 12 were sent to officers' training camps and 26 to Camp Custer, 10 having been rejected for physical defects.

The majority of the detachment saw service "over seas".

On July 19, a second detachment, of 500 men from Michigan, arrived for the auto-mechanics course, and was trained and transferred by September 13th.

On September 13th, 480 men from Michigan arrived, were still in training at the time of the armistice and were held here until finally discharged from service on December 17th.

About August 1st, 25 men were received for training as horseshoers and the same number as carpenters.

A total of 1504 men received vocational training.

By November 11, contracts had been closed and all arrangements made for training until June 30th, of this year, detachments of 400 auto-mechanics, 50 radio operators and mechanics, 50 topographers and 30 machinists, but of course we were requested to discontinue operations and "close up shop".

The Division of Veterinary Science cooperated effectively in the training of this group.

The district director of the Committee on Education and Special Training says of our work:

"From an organization stand-point there were no complaints made, no excuses offered, none were necessary. The efficient organization was peculiar in that all educational matters went from heads of departments to the Supervisor and then to the President. The President, Supervisor and Commanding Officer worked as a unit with the result that there were never any difficulties that were not anticipated and met before they matured.

"The main course was for auto-mechanics and special instructors were selected—many of the men having been released by manufacturers as their patriotic contributions to the war work. Practically without exception the instructors proved to be satisfactory. The course for horseshoers was on an excellent basis because of the sufficient number of horses to work upon and the assistance of the veterinary department.

"Most of the equipment was purchased for this work but part of it was loaned by cooperative manufacturers. Ample room was provided so that there was no crowding in any way of the educational work.

"The military and educational work was well balanced and there was no lag or lack of snap in either the educational or military work from start to finish."

3. *Exhibit "A"* appended hereto presents some personal observations on the work of Section B of the S. A. T. C. at M. A. C.

H. *Appreciation.*

I hereby record my appreciation of authorities, colleagues and students for their cooperation in "carrying on" during the past year which we will all remember as an arduous and eventful period in the history of the College and of the Division of Engineering.

Respectfully submitted,
GEORGE W. BISSELL,
Dean of Engineering.

East Lansing, June 30, 1919.

EXHIBIT "A".

"ANALYSIS OF METHODS WHICH RESULTED IN THE MAXIMUM OF VOCATIONAL EFFICIENCY IN SHORT COURSES."

By G. W. Bissell, East Lansing, Michigan, at a conference of specialists in Industrial Education, formerly connected with the S. A. T. C., Chicago, May 10, 1919.

My connection with the great work of vocational training of soldiers under the general direction of the Committee on Education and Special Training of the War Department was that of Supervisor of Vocational Training in the S. A. T. C. at the Michigan Agricultural College. A visit to Purdue University a short time after the work had begun there and before we had begun it, and a visit to the University of Michigan during July comprise the experience which I did not acquire by "doing" the work itself. I may perhaps be pardoned, therefore, if my paper discusses the assigned subject mainly from the standpoint of my own experience which I will relate briefly.

At the outset, I have no quarrel with the thesis. The work was highly satisfactory in the doing and in the results obtained so far as I know and can judge by what I have heard about it from others connected therewith.

The discussion divides itself more or less naturally into two parts:

1. The methods devised in *advance* of performance.
2. The methods devised by *experience in the performance.*

1. *The Methods Devised in Advance* were based upon:

(a) The general specifications of the committee as to the character of training, the field to be covered, the time allowed, the character of men to be instructed and the preparations of the men to receive the instruction.

(b) The creation of an organization, administrative and instructional to start the work and carry it on smoothly, capable of adjustment to the needs as revealed by experience.

(c) The material equipment available at the institutions or obtainable by the time needed.

(d) A relative short preparation period. Too much emphasis should not be placed on this, because as a matter of fact schools had bid for specific work several months in advance of contracts and had made tentative plans for doing it.

(e) Inexperience in vocational training. I believe it is generally true that the college teachers and practical men who were utilized in the training of soldiers had had no experience in vocational training.

(a) Valuable suggestions as to character of training were contained in the instructions of the Committee, formally issued, and verbally in interviews with the District Director, and from the various bulletins of the Federal Board of Vocational Education.

From these sources the course of study was first outlined and then modified by consideration of institutional facilities for the work.

At. M. A. C. the first job assigned by the Committee was that of training for auto-mechanics, detachments of 500 drafted men qualified by 8th grade schooling and mechanical training or aptitude, notification being received on April 22, a contract being signed on May 3, and the men being scheduled to arrive on May 15, and to depart on July 15.

It was decided to utilize an organization in the Farm Mechanics Deartment which had successfully carried on "short-course" work in gas tractors and small gas-engines for a number of years, and an excellent equipment and personnel in forge-work in the Mechanical Engineering Department. The outlines of the Federal Board of Vocational Education and the instructions of the committee were not in radical conflict with the above plans and we were able to draft thereby a number of our college personnel in the work, to their delight and with advantage to the *morale* of the whole undertaking as a college job.

The organization as finally worked out provided eight units of *instructional work.*

1. General chassis repair.
2. Chassis parts repair.
3. Engine repair.
4. Carburetor trouble and block test.
5. Ignition, lighting and starting.
6. Road trouble and driving.
7. Forge work.
8. Tractors and stationary gas engines.

The *instructional schedule* was *rotational* instead of *progressive* and was based upon the platoons of which there were eight, each consisting of eight squads, each squad being a teaching unit so far as the duplicated equipment and the number of instructors was concerned, except in the forge-shop, where individual equipment was available at the outset.

This scheme, in general and in detail, is very mechanical and might be criticised adversely on that score, but it worked so well when put in practice that its main features were adhered to until the war ended.

A very comprehensive recording system was devised to meet the requirements of the Committee.

(b) The administrative and teaching organization personnel was recruited from the college teaching personnel, from regular students, and from the outside.

Some outsiders were obtained from two automobile schools in Detroit, some from the waiting list of another institution, some from apprentice school-work in automobile factories, some from mechanics in factories and garages, local and outside, some from Selfridge Field Transport School, and an electrical expert was loaned for a few months by a local factory.

The men were picked as carefully as possible in the time available and only a few misfits were found.

The number of teachers procured for each instructional unit varied with the character of the work and the estimated chances of finding suitable soldier instructors.

Early in the game the proposed organization was disarmed. The diagram was not changed after its adoption before the coming of the first detachment.

The force was assembled gradually, the men assigned to specific positions and set to work preparing the equipment which was being assembled concurrently.

The initial staff consisted of about 50 persons. The working staff at M. A. C. in October consisted of:

M. A. C. teaching staff	11	
Clerical staff	8	
M. A. C. students	2	
Trade school men	5	
U. S. A. Transport men	2	
Practical men	17	
		45
Soldiers, instructors	26	
Soldiers, clerks	2	
		28
		73

The necessary relations and business with the military authorities were maintained by a committee consisting of the president of the college, the commanding officer and the supervisor. Frictionless cooperation resulted in all matters. Expenditures were controlled by the supervisor, the president and the secretary of the college. Purchases were made by the college purchasing agent and the supervisor classified the items of expense.

(c) The material equipment was obtained in various ways and from many sources. Army trucks arrived before the instruction began.

The work of instruction was based at the outset on the principle of "Learning by doing" but lectures and examinations were included as accessory means of imparting instruction.

2. *Methods Evolved by Experience.*

We found immediately that the soldiers were intensely interested and receptive, and that our chief concern was to be that they should have efficient instruction.

We found also that our instructors were extremely eager to do the best that could be done.

Our task was, therefore, that of training the instructors to the duties of the job which required:

1. Individual instruction, except in lectures.
2. Grading of the soldiers, in practice work and in examinations.
3. Cooperation.

This training was accomplished by:

1. Supervision, continually by the supervisor, chief instructor, recorder and the Commanding Officer.
2. By teachers' meetings.
3. Rotational instructors' schools.
4. Suitable forms for grading.

2. The teachers' meetings were held on Friday afternoons after class hours. Teaching problems, grading, discipline, etc., were presented and discussed or papers were prepared and read by some of the instructors on appropriate subjects or outsiders lectured.

3. Three afternoons each week, after class-work, the instructing force "went to school" in rotation, one or two weeks in each of the instructional departments. This promoted cooperation. Also the instructors attended the lectures given to the soldiers, in the subjects germain to their work.

The fifth afternoon was devoted to making or devising necessary changes in equipment to improve the work.

4. Individual grading was done at the end of each class day, the forms used, being provided with photo of the soldiers to assist in this task.

Another point developed from experience was that most of the soldiers wanted a text book of some kind. We procured and sold to them several hundred copies of Dyke's Encyclopedia and prepared, gratis, complete mimeograph notes in all departments.

The manuals issued by the Committee did not arrive in time for the first and second detachments and did not then meet our requirements, because they predicated "reading" before "doing" and this did not appeal to the soldiers, or to the instructors. These manuals were, however, very useful to the instructors from the "points" and suggestions contained as to the ground to be covered and the information and skill which the soldiers should have.

In tractor work a manual which had given good results with civilians was used for the soldiers.

Note books were furnished to soldiers and their use advised in some units such as ignition and lighting.

Experience showed that some instructors were not of the caliber or experience required, at least in the positions originally assigned to them. Transfers were made, involving sometimes demotion or promotion, and eventually some were released.

Soldier instructors were used to some extent from the first week and were fairly successful especially after they were given temporary "non com" rank and allowed to put in full time, including attendance on instructors' meetings and schools.

Since writing the above I have read Mr. Dooley's "Final Report" and I conclude that my experience has much in common with others similarly engaged.

An analysis of the general experience seems to me to show that the success which attended this large experiment in vocational training was due to:

1. Superior motivation.
2. Appropriate subject matter.
3. The application of sound principles of organization.
4. The application of sound pedagogic principles.
5. The disciplinary experience.

1. The motivation was two-fold—major and minor. The major motivation was the spirit to "win the war" which had awakened in the whole nation and was growing with tremendous speed and accomplishing wonders in all national undertakings. This spirit invested the very soul of soldier-students and was bound to produce results if the energy resulting was wisely directed.

The minor was the idea of learning something worth while by going to school without financial anxiety.

3. The principles of organization were business-like and applied, therefore, with directness and efficiency.

4. The pedagogical principle was that of "learning by doing" which is bound to produce better results with the majority of young men than an academic training.

5. Regular habits and duties have been preached by many but their benefits have never been so strikingly shown as in the work which we are discussing.

Reactions.

Our experiences will undoubledly react on educational methods of all kinds and in all branches of education.

Just now, many colleges are undergoing relapses from army discipline—such as more serious out-breaks of hazing and inter-class scraps than for many years past.

This is natural and will pass. Moreover, the colleges train only a very few relatively. The masses must be trained vocationally. The war has shown what can be done under the motivation of the war spirit. Let it be our task as a nation to lift up the industrial spirit to motivate vocational work.

If this can be done I feel sure that the experience that we have had with the soldiers will be very useful.

A useful reaction of the experience will appear in college training. Most of us learned much that will help us.

1. The advantage of individual instruction.
2. The importance of tying instruction to the student's previous experience, aptitude and sympathies.
3. The value of discipline.
4. The importance of vocational selection by systematic mental tests.
5. The necessity of revealing to the student as far as possible the practical value of the subject matter.

All of which we thought we had fully appreciated and about which we had certainly talked to the extent of "rain repetitions" but which we should know by experience.

REPORT OF THE DEPARTMENT OF CIVIL ENGINEERING.

President F. S. Kedzie, College.

Dear Sir—The first half of the college year just passed presents a record of uncertainty, distractions and an almost complete disorganization of the regular educational plan, so far as engineering courses are concerned. The year before had been bad enough, but a hopeful sign appeared in the deferred service regulations of the War Board. However, the summer of 1918 brought a shock in the dissipation of this one promise for the future and deferred service for engineering students was revoked. Without doubt the connection of the College with the war program will be given ample historical record elsewhere, but I desire to pay my respects to the short-sighted policy which could and did throw into the discard all systematic training of real engineers. Had the duration of the war extended for several years I wonder whence would have come the necessary supply of trained men in this line.

For the fall of 1918 all thought of following our normal schedule was abandoned, but the requirements of the S. A. T. C. program provided plenty of work for the teachers of this department. In these soldier classes there was no lack of earnest effort on the part of either instructors or students. In fact, all our teachers marveled at the eagerness generally shown by the students assigned to us for training. This manifestation of desire and receptivity died on the day that the armistice was announced so far as the majority of the students were concerned. They were more than ready to exert themselves to the utmost so long as their training could have possible use in the war program. When that possibility was removed the young men returned to their pre-war lines of thinking. Those who wanted to be physicians, lawyers, dentists or anything else than engineers, lost all interest in matters pertaining to engineering. It was an interesting study to note the remarkable transformation from classes uniformly earnest and purposeful to groups largely indifferent and apparently stupid when judged by the usual standards.

Both the epidemic of influenza and the military control mixed in with the educational program tended to annoy and confuse us in our attempts at a systematic management of class training. During the whole period of dealing with the S. A. T. C. classes in Surveying and Mapping, the membership of no class appeared the same on two consecutive days.

About two weeks before the S. A. T. C. class work was taken up on October 1, 1918 this department had been given general directions concerning the character of instruction to be arranged for soldiers and sailors. These instructions came from the war committee on education. From the same source we received assurances that other information would be supplied "in a few days" regarding outlines of courses, sample exercises and the like. It would have been fatal to wait for the promised material, and it is interesting to note that practically none of it arrived in 1918, while quantities of it did appear about the 1st of May 1919, more than five months after the armistice and nearly as long after the S. A. T. C. had become only a memory.

Courses had been prepared by the department, however, and such other preparations had been made that when the S. A. T. C. contingents were assigned to the department they found ready vigorous courses in the subjects taught in this department. We had been directed to prepare and did prepare for a special contingent under the vocational program, to whose members we were expected to give special training in topographical surveying. This contingent never arrived.

The department teaching staff for the year included the names listed below in the order of seniority of appointment. There were no changes or withdrawals during the year.

H. K. Vedder, C. E., Professor of Civil Engineering.
C. A. Melick, D. C. E., Associate Professor of Civil Engineering.
C. M. Cade, C. E., Assistant Professor of Civil Engineering.
R. G. Saxton, C. E., Assistant Professor of Civil Engineering.
W. W. Hitchcock, C. E., Instructor in Civil Engineering.
B. K. Philp, C. E., Instructor in Civil Engineering.
H. M. Ward, B. S., Instructor in Civil Engineering.
(On leave for military service).

By reason of his service in the Phillipine Constabulary, covering a period of about three years, Mr. H. M. Ward became eligible to a commission in the United States Army, and was appointed a Second Lieutenant in the

Reserves. He was secured by the civil engineering department as an instructor in the fall of 1916 while he was in the states on a furlough, and he then terminated his connection with the Phillipine Constabulary. When the United States entered the war with Germany Mr. Ward was the first man to be called from M. A. C. He left the college May 2, 1917 for active duty at Fort Snelling, Minn. He sailed for France June 13, 1917 with the 26th Infantry. His company later became a part of a machine gun battalion, and he took part in the fighting in numerous sectors including Soissons, St. Mihiel, Argonne, Mouzon and Sedan, besides serving for a time in the Army of Occupation. He became First Lieutenant in the field, and was discharged at Camp Custer, June 30, 1919.

Mr. Ward's position as instructor was kept open for him, and he seriously considered the resumption of his work in the department until a tempting offer caused him to take up practical engineering and to withdraw from his college connection.

All other members of the department staff stood ready to serve the country, and freely offered themselves for any duty that could promote the welfare of the United States in the great war. That our teachers with one exception were not called elsewhere was undoubtedly due to the fact that their usefulness was very properly held to be most efficiently applied when they directed their energies to the education of soldiers, as they did.

As has been noted, the fall term of 1918 beginning October 1st witnessed a merger of our engineering schedule with the war program. Nearly all phases of class instruction were adapted to meet the requirements of the S. A. T. C. All instruction of army units ceased in December, and we took up a regular college schedule on January 2, 1919. The winter term was occupied with the usual fall term program. The spring term was likewise given up to studies that normally appear in the winter. The arrangement of two summer terms in 1919, each six weeks long, made it possible for many engineering seniors to complete their work for graduation, and permitted lower classmen to make up the loss suffered by reason of the fall term army occupation. The subjects taught during the year by the department staff and the number of students in all classes are set forth below. Although the first summer term extends beyond the end of the fiscal year, it has seemed well to include it in this record since it completes a study year for a large percentage of our students.

FALL TERM.

Surveying and Mapping—2 hours in class, 6 hours in field, 114 students, 4 recitation sections, and 6 field sections, in charge of Messrs. Melick, Saxton, Philp and Hitchcock.

Mapping and Navigation—2 hours in class, 6 hours in field, 31 students, 1 section. Recitation work directed by Mr. Cade; field work, Messrs. Cade and Saxton.

C. E. 4a (*Mechanics of Engineering*)—5 recitation hours, 11 students, 1 section; Mr. Vedder.

C. E. 5 (*Hydraulics*)—5 recitation hours, 3 students, 1 section; Mr. Vedder.

Mathematics for Soldiers—5 hours recitation per week, 17 students, 1 section; Mr. Philp.

C. E. 6 (*Advanced Surveying*)—2 hours in class, 4 hours in field, 6 students, 1 section; Mr. Vedder.

WINTER TERM.

C. E. 3 (*Agricultural Engineering*)—5 recitation hours, 10 students, 1 section; Mr. Vedder.

C. E. 4a (*Mechanics of Engineering*)—5 recitation hours, 22 students, 2 sections; Mr. Philp, Mr. Saxton.

C. E. 4b (*Mechanics of Engineering*)—5 recitation hours, 11 students, 1 section; Mr. Melick.

C. E. 4d (*Graphics of Framed Structures*)—3 recitation hours, 6 students, 1 section; Mr. Melick.

C. E. 5 (*Hydraulics*)—5 recitation hours, 14 students, 1 section; Mr. Saxton.

C. E. 5a (*Hydraulic Laboratory*)—4 laboratory hours, 6 students, 1 section; Mr. Saxton.

C. E. 7a (*Topographic Mapping*)—6 laboratory hours, 4 students, 1 section; Mr. Cade.

C. E. 8a (*Bridge Stresses*)—3 recitation hours, 6 students, 1 section; Mr. Vedder.

C. E. 12 (*Experimental Laboratory*)—6 laboratory hours, 6 students, 1 section; Mr. Hitchcock.

Drawing & Design 3a—6 laboratory hours per week, 16 students, 1 section; Mr. Philp.

Drawing & Design 4a—8 laboratory hours per week, 26 students, 1 section; Mr. Cade.

Drawing & Design 7—6 laboratory hours per week, 6 students, 1 section; Mr. Hitchcock.

SPRING TERM.

C. E. 1b (Surveying & Leveling)—2 hours in class, 4 hours in field, 41 students, 3 recitation sections, 3 field sections, in charge of Messrs. Cade, Philp and Hitchcock.

C. E. 2 (Surveying Methods)—3 hours in class, 4 hours in field, 4 students, 1 section; Mr. Vedder.

C. E. 4b (Mechanics of Engineering)—5 recitation hours, 21 students, 2 sections; Mr. Saxton, Mr. Hitchcock.

C. E. 4c (Strength of Materials)—5 recitation hours ten students, 2 sections; Mr. Philp.

C. E. 6 (Advanced Surveying)—3 hours in class, 4 hours in field, 18 students, 4 recitation sections, 4 field sections, in charge of Messrs Cade and Hitchcock.

C. E. 6a (Topographic Mapping)—2 hours in class, 4 hours in field, 7 students, 1 section; Mr. Cade.

C. E. 6b (Higher Surveying)—1 hour in class, 4 hours in field, 6 students, 1 section; Mr. Vedder.

C. E. 8b (Bridge Analysis and Design)—8 laboratory hours, 6 students, 1 section; Mr. Melick.

C. E. 9 (Masonry and Arches)—3 hours in class, 4 hours in laboratory, 6 students, 1 section; Mr. Melick.

C. E. 10 (Pavements)—2 recitation hours, 14 students, 1 section; Mr. Saxton.

C. E. 14 (Astronomy)—2 hours in class, 2 hours in field, 10 students, 1 section; Mr. Vedder in class, assisted by Mr. Philp in field.

C. E. 15 (Water Supply and Sewerage)—4 recitation hours, 8 students, 1 section; Mr. Saxton.

C. E. 17 (Road Construction)—2 hours in class, 6 hours in field, 10 students, 1 section; Mr. Saxton.

FIRST SUMMER TERM.

C. E. 4c (Strength of Materials)—10 recitation hours per week, 19 students, 2 sections; Messrs. Saxton and Philp.

C. E. 7 (Railroad Surveying)—6 hours in class, 8 hours in field, 5 students, 1 section. Recitation work directed by Mr. Saxton; field work, Messrs. Saxton and Philp.

C. E. 11 (Thesis)—40 laboratory hours per week, 5 students, 1 section; Mr. Vedder.

C. E. 13 (Contracts and Specifications)—6 recitation hours per week, 16 students, 1 section; Mr. Vedder.

For all army courses in surveying the texts used were Leach's Engineer Field Manual and Connor's Military Railways. Other text-books used during the year were Merriman & Jacoby's Roofs and Bridges, Vols. I, II, III; Vedder's Notes on Surveying, Daugherty's Hydraulics, Hancock's Mechanics, Baker's Masonary Construction; Harger and Bonney's Highway Engineers' Handbook, Turneaure and Russell's Public Water Supplies, Folwell's Sewerage, Hosmer's Astronomy, Tucker's Contracts in Engineering, Boyd's Strength of Materials, Allen's Railroad Curves and Earthwork, Breed and Hosmer's Surveying, Vols. I, II; Ingram's Geodetic Surveying and Blanchard and Drowne's Highway Engineering.

The total expenditure by the department during the year for all purposes has been $1,109.80. During the same period the sum of $127 has been turned in for class and examination fees.

Respectfully submitted,
H. K. VEDDER.
Professor of Civil Engineering.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Dr. F. S. Kedzie, President, Michigan Agricultural College.

Dear Sir—I am submitting the following report of the work of the Department of Mechanical Engineering for the year ending June 30, 1919.

The personnel of the department at the end of the year was as follows:

H. B. Dirks, Professor of Mechanical Engineering.
Appointed May 1, 1919.
W. E. Reuling, Assistant Professor of Mechanical Engineering.
A. P. Krentel, Foreman of Wood Shop.
G. J. Posthumus, Instructor in Wood Shop.
G. C. Wright, Foreman in Machine Shop.
R. G. Bigelow, Instructor in Machine Shop.
J. A. Eicher, Foreman in Foundry.
W. G. Hildorf, Foreman in Forge Shop.
Andrew Watt, Instructor in Forge Shop.
E. C. Crawford; Laboratory Engineer.
J. F. Hineline, Mechanician.
C. N. Rix, Storekeeper.

Mr. J. A. Polson, formerly head of the department, resigned on March 1, 1919, giving up his teaching work to enter the field of the manufacturing industry. As the new head was not appointed until May 1st, the direction of the department was in the hands of Dean Bissell until that time. The courses formerly taught by Professor Polson were handled as follows: ME-5a, Works Management, by Mr. Wright, ME-17a, Thermodynamics, by Mr. Field, and ME-13d, Engineering Laboratory, by Mr. Reuling. I wish to express my appreciation of this extra work by the above men.

Mr. G. H. Peters, formerly Instructor in Wood Shop, resigned on March 15, 1919. His place was not filled and necessitated the carrying of an added burden by Mr. Krentel and Mr. Posthumus, for there were 131 students registered in the Wood Shop courses in the third term. Appreciation of this added work is acknowledged.

On account of the forming of the Students Army Training Corps, there was very little of the fall term college work given, as indicated in Table I. The regular work was replaced by specified courses laid down by the Government, which varied with the age of the student and the branch of training to be followed.

In January the S. A. T. C. was abandoned, and the regular fall term college work was taken up. The winter term's work was taken up in spring, and the spring terms work is being completed during the summer, so that by next fall, it is hoped, most of the irregularities due to the war will have disappeared.

In addition to the regular college work and that of the S. A. T. C., a great deal of work was done by members of the department in connection with the training of the soldiers in the Auto Mechanics Training School, established here by the government beginning May 15, 1919, and which continued for three terms, viz., May 15 to July 15, July 15 to September 15, and September 15 until November 15, 1918. The following is a list of the instructors in this work, and represents their contribution to the war activities of the country.

J. A. Polson, Chief Instructor in Shop Courses.

G. C. Wright, Assistant Instructor in Shop Courses.

W. E. Reuling, Instructor in Farm Tractors and Gas Engines, 1st and 2nd terms, Instructor in Mathematics in S. A. T. C. during 3rd term.

J. Hineline, Instructor in Carburetion and Block tests during 1st term, and Instructor in Road Trouble during 2nd and 3rd term.

W. G. Hildorf, Instructor in Forging and Welding and Frames and Front Axle Repairs, during all three terms.

G. J. Posthumus, Instructor in Chassis Repairs, Rear axles and Springs, during 2nd and 3rd terms.

Andrew Watt, Instructor in Forging and Welding—during all terms.

E. C. Crawford, Storekeeper—three terms.

R. C. Bigelow, Machinist (Enlisted as soldier, but transferred here for special service).

A. P. Krentel, Superintendent of building of Barracks and garage.

J. A. Eicher, Assistant Storekeeper, during 3rd term—Employed in Ford foundry on castings for Eagle boats, during 1st and 2nd term.

During the year new equipment has been obtained for additional work in the heat treatment of steel, and also two crucible furnaces, for the foundry work in brass and the soft metal alloys.

I wish to call attention to the needs of the department for further equipment in the machine shop so that our students may be better able

to understand and to help solve problems, in the modern methods of manufacture, and also for further equipment in our laboratory necessary for the study of power production and transmission machinery, the strength of materials, and power plant work, including the economical use of fuels.

The class work of members of the department is given in the tables that follow.

Respectfully submitted,
H. B. DIRKS,
Professor of Mechanical Engineering.

East Lansing, June 30, 1919.

TABLE I.

Class Work of Department of Mechanical Engineering, Fall Term, 1918.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students.	Student hours per week.
Freshmen	Elements of Engineering	1	Dean Bissell	1	26	26
Freshmen	Wood Shop	2a	Mr. Krentel, Mr. Peters	6	49	294
Freshmen	Farm Mechanics	2d	Mr. Krentel, Mr. Peters	6	29	174
Seniors	Gas Power Engineering	8c	Prof. Reuling	3	3	9
Total					107	503

TABLE II.

Class Work of Department of Mechanical Engineering, Winter Term, 1918.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students.	Student hours per week.
reshmen	Elements of Engineering	1	Dean Bissell	1	77	77
reshmen	Woodshop	2a	Mr. Krentel, Mr. Posthumus Mr. Peters	6	81	764
reshmen	Woodshop	2b	Mr. Krentel, Mr. Posthumus Mr. Peters	6	47	
ophomore	Forge Shop	3ab	Mr. Hildorf, Mr. Watt	6	25	464
uniors	Forge Shop	11a	Mr. Hildorf, Mr. Watt	2	33	
ophomore	Foundry	4ab	Mr. Eicher	6	25	150
uniors	Engineering Laboratory	7a	Mr. Reuling	3	30	
uniors	Engineering Laboratory	13a	Mr. Reuling	4	26	392
eniors	Gas Power	8c	Mr. Reuling	3	9	
eniors	Engineering Laboratory	13c	Mr. Reuling	4	21	480
eniors	Engineering Laboratory	13d	Mr. Reuling	6	2	
uniors	Machine Shop	2h	Mr. Wright, Mr. Bigelow	6	29	228
eniors	Machine Shop	2k	Mr. Wright, Mr. Bigelow	6	9	
uniors	Works Management	5a	Mr. Wright, Mr. Bigelow	3	1	
uniors	Heating and Ventilating	18c	Prof. Polson	3	7	21
eniors	Thesis	19a	Prof. Polson	20	1	20
. Women	Woodshop	21a	Mr. Krentel, Mr. Posthumus Mr. Peters	4	5	20
Total					428	2,616

TABLE III.

Class Work of Department of Mechanical Engineering, Spring Term, 1919.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students.	Student hours per week.
Freshmen....	Woodshop	2a	Mr. Krentel, Mr. Posthumus	6	1	
Freshmen....	Woodshop	2b	Mr. Krentel, Mr. Posthumus	6	76	912
Freshmen....	Woodshop	2c	Mr. Krentel, Mr. Posthumus	6	51	
Sophomore...	Forge Shop	3a	Mr. Hildorf, Mr. Watt	6	20	
Sophomore...	Forge Shop	3c	Mr. Hildorf, Mr. Watt	6	26	312
Seniors......	Forge Shop	2b	Mr. Hildorf, Mr. Watt	6	6	
Sophmore...	Foundry	4a	Mr. Eicher	6	23	
Sophmore...	Foundry	4c	Mr. Eicher	6	22	270
Juniors......	Machine Shop	2i	Mr. Wright, Mr. Bigelow	6	20	
Seniors......	Machine Shop	2k	Mr. Wright, Mr. Bigelow	6	1	165
Seniors......	Machine Shop	2l	Mr. Wright, Mr. Bigelow	6	4	
Seniors......	Machine Shop	5a	Mr. Wright, Mr. Bigelow	3	5	
Juniors......	Thermo-dynamics	17a	Prof. Field	4	21	88
Seniors......	Thermo-dynamics	17a	Prof. Field	4	1	
Juniors......	Engineering Laboratory	13a	Prof. Reuling	4	3	
Juniors......	Engineering Laboratory	13b	Prof. Reuling	4	24	218
Seniors......	Engineering Laboratory	13d	Prof. Reuling	8	14	
Freshmen....	Farm Mechanics	2d	Mr. Krentel, Mr. Posthumus	6	24	144
Freshmen....	Farm Mechanics	3d	Mr. Hildorf, Mr. Watt	6	64	384
Jr. Women...	Woodshop	21b	Mr, Kentrel	2	3	6
Seniors......	Fower Station Design	18b	Dean Bissell	7	13	91
Total...					421	2,590

REPORT OF THE DEPARTMENT OF ELECTRICAL ENGINEERING.

President F. S. Kedzie, College.

Dear Sir—At the time of my last report, the United States was at war, and the department was holding itself in readiness to train men for Signal Corps work in the army. Our whole staff remained on duty during the summer ready to give instant service in the war work. We expected to have 75 or 100 men in training for the Signal Corps, but before they arrived the armistice was signed.

Mr. Andres of the Department of Electrical Engineering assisted in the electrical instructional work of the Motor Mechanics School, being engaged in that work until the 11th of October. Since that date we have been endeavoring to get readjusted to peace conditions. It meant the rearranging of apparatus, and the renewing of our equipment (which had been previously depleted by the fire of 1916).

After the armistice was signed, in order to encourage former students to return to college, the faculty very promptly promised them that upon their return classes would be provided for them, so that they could go on with their regular college work with a minimum of interruption. That promise resulted in pretty strenuous times for every department, and necessitated broadening the scope of the work of the Summer School, this year, as a very large proportion of the students missed their fall term's work, and would be obliged to attend Summer School in order to be ready for their regular classes this fall (1919).

In the fall of 1917, Mr. P. G. Andres left his teaching work in the Northern Peninsula to help the College with its radio telegraphic work which provided instruction in telegraphy for all the students who desired to prepare for that line of service, during the period of the war. As stated

earlier in my report, he assisted in the electrical instructional work in connection with the U. S. Army School of Motor Mechanics under the direction of the Mechanical Engineering Department.

From July 18 to September 16, Mr. M. M. Cory, of the department, attended the S. A. T. C. camp at Fort Sheridan, Illinois, where he received special instruction in liaison work. On his return to the College, he assisted the Military Department throughout the duration of the war, and for a time after its close.

Very respectfully submitted,
A. R. SAWYER,
Professor of Electrical Engineering.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF DRAWING AND DESIGN.

President F. S. Kedzie, Michigan Agricultural College.

Dear Sir—I herewith present to you my third annual report as head of the Department of Drawing and Design for the year ending June 30, 1919.

During the period from May 15 to December 15, 1918, I served the College in the capacity of Record Keeper for the Vocational Section of the Student Army Training Corps, in addition to my regular duties connected with the Drawing Department. A complete record of the individual work carried on daily by each student was kept in my office and from these records frequent reports were sent to Washington, and the boys aptitude along certain mechanical lines was determined. At the end of each two months the men were grouped according to their abilities and sent out into the service of the government. There were 1626 men who were inducted into the service and whose records are on file in my office.

Work was offered in the fall term to members of the Student Army Training Corps (S.A.T.C.) as shown in the Teaching Schedule attached to this report. Every effort was made to correlate the work with the outlines as submitted by the Committee on Education and Special Training and at the same time we had in mind the possibility of substituting this work for college credit at some future time.

There were some sections of regular college students enrolled and our total for the fall term including both groups, was 375 as compared with 294 the preceding year.

Mr. L. N. Field served as one of the lecturers in the Vocational Section from May 15 to December 15, 1918.

Mr. J. W. Steward served as an instructor in the Tractor and Gas Engine Department throughout the summer.

The personnel of the department at the opening of the fall term was as follows:

Mr. R. K. Steward, Professor.
Mr. Chase Newman, Associate Professor.
Mr. L. N. Field, Associate Professor.
Mr. J. W. Steward, Assistant Professor.
Mr. A. G. Scheele, Assistant Professor.
Miss Caroline L. Holt, Instructor.
Mr. E. H. Stewart, Instructor.
Mr. Justus Rising, Instructor.
Miss Edith Butler, Assistant Instructor.

Mr. Alfred Iddles, Assistant Professor, was given a leave of absence February 15, 1918, and resigned December 26, 1918.

Mr. F. D. Messenger was given a leave of absence on May 4, 1918 and resigned January 8, 1919.

Mr. M. B. Chapin was drafted November 16, 1917 and has been overseas in service. He returned to this country the last of April and it is hoped that he will return to take up his work teaching in the department in the fall.

I wish to express to the Department of Civil Engineering my appreciation for the services of Messrs. C. M. Cade, W. W. Hitchcock and B. K. Philp, who assisted us during the winter term.

In my report of last year I stated that plans were being worked out for the development of courses along art lines, and I am pleased to state that through the efforts of Mr. Scheele, and the cooperation of the Department of Household Art, outlines for additional courses have been presented to and approved by the faculty, so that, commencing next fall, the freehand work will be required of freshmen women during the first two terms.

In the fall term sophomore year, a girl who is interested in drawing and painting may elect work in these lines and continue it throughout her college course if she wishes. This will include courses in History of Art, History of American Art and History of American Paintings.

There have been several changes in the courses given to the women students to correlate more closely the work of the Household Art and Drawing Departments.

There has also been approved by the faculty, certain changes in the arrangement as well as context of drawing courses offered to the freshmen and sophomore engineering students, and I feel that these changes are going to increase the efficiency of the department in its dealings with engineering students.

The blue printing department has completed another satisfactory year from a financial standpoint, and has served a number of departments about the College.

In closing permit me to bear testimony to the uniform support which I have been given by the members of the department staff.

The following is a teaching schedule of the department:

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN.
FALL TERM, 1918.

Class.	Subject.	No.	Instructor.	Hours.	No of Students.
Freshmen	Mechanical Drawing	4ab-1	C. Newman	6	28
Freshmen	Mechanical Drawing	4ab-2	L. N. Field	6	22
†Sophomores	Machine Design	6a	J. W. Steward	6	23
Sophomores	Freehand Drawing	1b-1	A. G. Scheele	10	16
Sophomores	Freehand Drawing	1b-2	C. L. Holt	10	15
*18 years	Mechanical Drawing	I	E. H. Stewart, R. K. Steward	3	35
*18 years	Mechanical Drawing	IIa	J. W. Steward	3	24
*18 years	Mechanical Drawing	IIb	E. H. Stewart	3	18
*18 years	Mechanical Drawing	III	E. H. Stewart, C. Newman	3	30
*18 years	Mechanical Drawing	IVa	C. Newman	3	16
*18 years	Mechanical Drawing	IVb	E. H. Stewart	3	22
*19 years	Mechanical Drawing	"Eng."	R. K. Steward, J. W. Steward	4	32
*19 years	Mechanical Drawing	"T"	L. N. Field, C. Newman	3	37
*20 years	Mechanical Drawing	"Eng."	J. W. Steward	6	32
*20 years	Mechanical Drawing	"Ord"	C. Newman	4	3
*20 years	Mechanical Drawing	"T"	C. Newman	6	22
(o)	Lectures in Vocational Work		L. N. Field	12	140
(o)	Record Keeper		R. K. Steward		546
Total					1,061

*Class "A" S. A. T. C.
†Combination of Class "A" and regular students.
(o) Class "B" S. A. T. C.

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN.
WINTER TERM, 1919.

Class.	Subject	No.	Instructor.	Hours.	No. of Students.
Freshmen	Mechanical Drawing	3a-2	J. W. Steward	6	16
Freshmen	Freehand Drawing	3a-2	Miss C. Holt A. G. Scheele Edith Butler	4	16
Freshmen	Mechanical Drawing	3a-3	B. K. Philp	6	16
Freshmen	Freehand Drawing	3a-3	Miss C. Holt A. G. Scheele Edith Butler	4	16
Freshmen	Mechanical Drawing	3a-4	J. W. Steward	6	17
Freshmen	Freehand Drawing	3a-4	Miss C. Holt A. G. Scheele Edith Butler	4	17
Freshmen	Mechanical Drawing	4ab-4a	E. H. Stewart	6	15
Freshmen	Mechanical Drawing	4ab-4b	C. Newman	6	13
Freshmen	Mechanical Drawing	4e-1	L. N. Field	8	12
Freshmen	Mechanical Drawing	4e-2	E. H. Stewart	8	14
Freshmen	Mechanical Draing	4e-3	C. Newman	8	16
Freshmen	Mechanical Drawing	4e-4	R. K. Stewart, Justus Rising	8	14
Freshmen	Mechanical Drawing	4e-5	E. H. Stewart	8	21
Freshmen	Mechanical Drawing	4e-6	C. M. Cade	8	26
Sophomores	Machine Design	6a-1	J. W. Steward	6	12
Sophomores	Machine Design	6a-2	Justus Rising	6	8
Sophomores	Machine Design	6b	L. N. Field, Justus Rising	6	21
Juniors	Kinematics	6c	L. N. Field	4	6
Juniors	Machine Design	6d	L. N. Field	3	4
Juniors	Perspective	7	W. W. Hitchcock	3	6
Juniors and Seniors	Freehand	1h	A. G. Scheele	7	42
Juniors and Seniors	History of Art	2b	Miss Holt	5	10
Seniors	House Design	9-1	R. K. Steward	6	16
Seniors	House Design	9-2	C. Newman	6	21
Total					354

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN.
SPRING TERM 1919.

Class	Subject.	No.	Instructor.	Hours.	No. of Students.
Freshmen	Mechanical Drawing	3a-1	C. Newman	6	15
Freshmen	Freehand Drawing	3a-1	Miss C. Holt, A. G. Scheele, Edith Butler	4	15
Freshmen	Mechanical Drawing	3a-5	J. W. Steward	6	20
Freshmen	Freehand Drawing	3a-5	Miss C. Holt, A. G. Scheele, Edith Butler	4	20
Freshmen	Mechanical Drawing	3a-6	C. Newman	6	18
Freshmen	Freehand Drawing	3a-6	Miss C. Holt, A. G. Scheele, Edith Butler	4	18
Freshmen	Mechanical Drawing	4e-1	C. Newman	8	13
Freshmen	Mechanical Drawing	4e-2	Justus Rising	8	13
Freshmen	Descriptive Geometry	5ab-3	E. H. Stewart	6	15
Freshmen	Descriptive Geometry	5ab-4	R. K. Steward	6	9
Freshmen	Descriptive Geometry	5ab-5	E. H. Stewart	6	22
Freshmen	Descriptive Geometry	5ab-6	R. K. Steward	6	13
Freshmen	Descriptive Geometry	5ab-7	R. K. Steward	6	16
Freshmen	Descriptive Geometry	5ab-8	E. H. Stewart	6	16
Sophomores	Machine Design	6b-2	J. W. Steward	6	13
Sophomores	Machine Design	6b-3	Justus Rising	6	10
Juniors	Kinematics	6c	L. N. Field	4	2
Juniors	Machine Design	6d-4	L. N. Field	3	5
Juniors and Seniors	Freehand Drawing	1e	Miss C. Holt, A. G. Scheele	6	9
Juniors and Seniors	Freehand Drawing	1L	Miss C. Holt, A. G. Scheele	6	16
Juniors and Seniors	History of American Art	2d	Miss C. Holt	3	21
Seniors	Engine Design	8b	L. N. Field	8	4
Juniors	Thermodynamics	ME 17a	L. N. Field	4	22
Total					325

Respectfully submitted,
R. K. STEWARD,
Professor of Drawing and Design.

East Lansing, June 30, 1919.

REPORT OF THE DEAN OF HOME ECONOMICS.

President Frank S. Kedzie, Michigan Agricultural College.

My dear President Kedzie—Permit me to present the following report for the Division of Home Economics for the year 1918-19.

The *enrollment for the year was as follows:*

Graduate	1
Seniors	48
Juniors	65
Sophomores	58
Freshmen	97
Special Students	5
Summer Session 1919	127

A number of changes were made in the regular course of study. Courses in applied design, costume design and millinery have been added to the work in Household Arts and a course in advanced nutrition and dietetics to the work in Household Science.

A special course has been outlined in the junior and senior years for those wishing to specialize in vocational teaching.

The course of study now stands as follows:

FRESHMAN YEAR.

Fall Term

Mathematics 1 — College Algebra	5(5–0)
English 8j — Composition	5(5–0)
Household Art 1a — Sewing	5(2-6)
Drawing 1b — Freehand	3(0–6)
Household Art 10a — Design	2(0–4)
Physical Training a	
	20

Winter Term

Chemistry 1a — General Elementary	5(4–2
English 8k — Composition or Mathematics 2 — Trigonometry	5(5–0
Household Art 1b — Sewing	5(2-6
Drawing 1h — Freehand Drawing	2(0–4
Household Arts 10b — Design	3(0-6
Physical Training b	
	20

Spring Term.

Chemistry 9 — Qualitative Analysis	5(0–10)
English 81 — Composition or Mathematics 3 — Analytic Geometry	5(5–0)
Household Science 1a — Foods	5(2–6)
History 2 — Nineteenth Century	5(5–0)
Physical Training c	
	20

SOPHOMORE YEAR.

Fall Term

Chemistry 10 — Organic Chemistry	5(3–4)
Bacteriology 1 — General Bacteriology	5(5–0)
Household Science 1b — Foods	5(2–6)
*History 1 — Contemporary European	5(5–0)
Physical Training d	
	20

Winter Term.

Bacteriology 2 — Morphological and Cultural	5(0–10
Physics 3e — Heat	5(3-4)
Household Science 1c — Foods	5(2–6
*Economics 8 — Principles of Sociology	5(5–0
Physical Training e	
	20

Spring Term.

Physics 3d — Sound and Light	5(4–2)
Economics 9 — Elements of Economics	5(5–0)
Household Art 3 — Textiles	5(2–6)
*English 8h — Advanced Composition	5(5–0)
Physical Training f	
	20

*Sophomores who wish to do so, may, with the written recommendation of the department concerned and the consent of the dean of the division, take a modern language, continue work in mathematics or drawing or begin one of the elective sciences in which there is a sequence of three terms' work, substituting the same for History 2 (Fall Term), Economics 8 (Winter Term) and English 8h (Spring Term). All students making this substitution are expected to carry the subject substituted for three consecutive terms of the year.

JUNIOR YEAR.

Required Work.

Fall Term.

Household Art 4 .... 3(1–4)
Costume Design
and
Household Science 3 .... 2(2–0)
Household Management
or

Household Science 4 .... 5(2–6)
Advanced Cookery
Physiology 1b .... 5(3–4)
Physical Training g

15

Winter Term.

Household Art 2a .... 5(1–8)
Clothing
Chemistry 21a .... 5(2–6)
Physiological Chemistry
Physical Training h

10

Spring Term.

Household Art 2b .... *5(1–8)*
Clothing
Chemistry 21b .... *5(1–8)*
Physiological Chemistry
Physical Training i

10

SENIOR YEAR.

Required Work.*

Fall Term.

Household Science 8a .... 5(3–4)
Dietetics
Physical Training j

Winter Term.

Household Science 8b .... 5(2–6)
Dietetics
or
Household Art 7 5(1–8)
House Furnishing
or
Household Science 5 5(2–6)
Institutional Management
Physical Training k

Spring Term.

Elective.

* Fifteen technical credits will be required for the senior year.

COURSE OF STUDY FOR THOSE WISHING TO SPECIALIZE IN VOCATIONAL TEACHING.

Freshman and Sophomore years same as regular course.

JUNIOR YEAR.

Required Work.

Fall Term.

Household Art 4................3(1-4)
Costume Design
Household Science 3............2(2-0)
House Management
Household Science 4............5(2-6)
Advanced Cookery
Physiology 1b..................5(3-4)
Anatomy and Physiology
Education 1....................5(5-0)
Physchology
Physical Training g

Winter Term.

Household Art 2a...............5(1-8)
Clothing
Household Science 2............2(2-0)
Home Nursing
Chemistry 21a..................5(2-6)
Physiological
Education 2a...................5(5-0)
Science of Education
Physical Training h

SPRING TERM.

Household Art 2b...............5(1-8)
Clothing
Chemistry 21b..................5(1-8)
Physiological
Education 1a...................5(5-0)
Home Economic Teaching
Physical Training i

SENIOR YEAR.

Fall Term.

Household Science 8a...........5(3-4)
Dietetics
*Household Science 7...........5(0-10)
Problem Cookery
Household Science 9............2
Practice Housekeeping
Education 3a...................3
Practice Teaching
Drawing and Design 9...........3(0-6)
House Architecture
Household Art 5................2(0-6)
Applied Design
†Household Art 9...............3(0-6)
Millinery
Physical Training j

Winter Term.

Household Science 8b...........5(2-6
Dietetics
Household Art 7................5(1-8)
House Furnishing and Decoration.

Household Science 5............5(2-6)
Institutional Management
Physical Training k

Spring Term.

Household Art 8................5(0-10)
Advanced Clothing
†Household Art 9...............3(0-6)
Millinery
Household Art 5................2(0-6)
Applied Design
Education 3....................5(5-0)
History of Education

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* Elective any term of Senior year.
† Elective either Fall or Spring Term.

There have been several changes in the instructional force of the division during the year. Miss Winifred S. Gettemy was appointed head of the Domestic Art Department to take the place of Mrs. Lillian L. Peppard. Miss Gettemy has had special training along the lines of applied art, color and design and interior furnishing and decoration and has been able to develop this work in a very interesting manner. A start has been made toward collecting permanent exhibit materials for classes in these studies. Miss Zella Bigelow, instructor in Domestic Art, has been on leave of absence doing research work for the National Board for Vocational Education. Mrs. Paul Miller and Mrs. C. E. Millar have taken charge of classes during her absence. Miss Anna Bayha was added to the staff of the Domestic Art Department at the beginning of the second term.

Miss Hilda Faust was appointed Assistant Professor of Domestic Science and given charge of the work in problem cookery. A small research laboratory was started in connection with this work. This room is only partially equipped, but it is expected that additional equipment will be added each year as the work develops. The marked interest which the young women of the College have shown in this phase of the work and the excellent results obtained have been a gratification to all members of the department.

We hope to start during the next year a laboratory of mechanical household devices to be used by classes in household and institutional management.

We regret very much the resignation of Miss Edna Garvin, Associate Professor of Domestic Science, who has served the College so faithfully and efficiently during the past four years. Recognition and words of praise are due Miss Edith Casho, Mrs. Norma Gilchrist Roseboom and Miss Gettemy for the beautiful pageant produced on the campus at commencement time. Every one is delighted with the progress which the young women have made in swimming under the direction of our new instructor in Physical Education, Miss Helen Grimes.

Miss Mabel Williams, who has had charge of the Senior House during the past two years, has been called home, and Mrs. Mildred Osband has been appointed in her place. Mrs. C. L. Lewerenz has had charge of the young women at Eunomian House and Miss Springstein those at Hesperian House. These houses will not be available for girls during the coming year, and Abbott Hall will again be used for a girls' dormitory. Miss Eudora Savage is to take the place of Miss Annie Howard as Dean of Women.

It has been a matter of considerable gratification that the work of the division has been so thoroughly and completely carried out during the past year. My co-workers were untiring in their efforts to make the year the best that young women have known at M. A. C. I desire to express my appreciation of their hearty spirit of cooperation and faithful service.

To you also I am indebted for your thoughtful interest and cooperation in developing the work of the division.

Respectfully submitted,
MARY E. EDMONDS,
Dean of Home Economics.

East Lansing, June 30, 1919.

REPORT OF THE DEAN OF THE VETERINARY DIVISION.

President F. S. Kedzie, Michigan Agricultural College.

Dear President Kedzie—I have the honor, sir, to submit herewith my annual report for the year ending July 1, 1919.

The very unusual and disturbed conditions incident to the world war had their influence on college work in no small degree. At the very opening of the fall term students of the Veterinary Division, as was the case in other divisions of the college, were enlisted into the Student Army Training Corps. At that time fully eighty percent of upper class veterinary students were already a part of the United States Military Organization, having been inducted into the Medical Enlisted Reserve Corps during December of the previous college year and from which they were transferred in early October to the S. A. T. C.

Because of the large percentage of students previously enlisted in various phases of army service, enrollment among the upper classes (as was anticipated) last fall fell far below preceding years characterized by a steady increase in numbers; also, the freshmen class failed to reach our anticipations as based upon the evident favorable opportunities apparent in veterinary fields but which, like other phases of college work had little influence in vocational selection during the past year. Our total enrollment fell approximately 50%. In spite of these conditions and though many of the class of 1919 relinquished college work to serve their country, the number graduated in June constituted the largest group of young men given the D. V. M. degree at a commencement period since the establishment of the division in 1910 and of the number over one half are planning to enter general practice.

Now that conditions are slowly becoming normal enlisted men rapidly being demobilized and veterinary fields offering especially attractive vocational features we should, with proper advertising, look for rapid increase in student enrollment. In this respect the advertising campaign begun this year, though delayed in its fulfillment, should do much if continued for a few years toward attracting young men to the veterinary medical course at M. A. C.

With approximately 20% of efficiently qualified veterinarians answering their country's call, 87% of the graduates of M. A. C. Veterinary Division entered military service and many, with rank, pay and allowances of commissioned officers, saw service in Europe within the Federal Veterinary Reserve Corps.

The teaching schedule for the year was severely jolted at the very opening of the fall term. Under direction of the Surgeon General, United States War Department, whose office had taken over dictation of all phases of medical education for enlisted men, placed upon inactive lists to complete their studies, our published course was altered to facilitate adherence to prescribed work; inasmuch as the armistice was declared prior to the winter term, we were enabled to readjust a greater part of the work and finished the year with but slight deduction from regular courses.

Though the need for properly qualified veterinarians threatened, in fact did make inroads upon the teaching staff of the division, the early secession of hostilities made possible a timely return and further enabled augmenting our staff by the engagement of Lieut. R. A. Runnells in the Department of Animal Pathology at the beginning of the present calendar year; Dr. Runnells graduated from the division in 1916.

Russell Alger Runnells, a 1st Lieutenant in the Veterinary Corps, entered the service July 12th, 1917 and served five months as Veterinary Officer for the Medical Officers Training Camp, Ft. Benj. Harrison, Ind.; three weeks on duty at the Surgeon General's Office, Washington, D. C.; eight months at the Remount Depot, Camp Meade, Md.; four months on the staff at Veterinary Officers Training Camp, Camp Lee, Va. He was discharged from service January 6, 1919.

James William Benner, 2nd. Lieutenant of the Veterinary Corps of Company 45, Battalion 12 was in the service from August 15, 1918 to December 20, 1918. He was quizz-master of Medical Officers Training Corps, Ft. Oglethorpe, Ga.

Adding to the personnel of the Department of Animal Pathology made it possible for Professor Hallman to devote a large portion of his time for much needed research work upon diseases of the reproductive organs of breeding cattle; a condition having now a special significance incident to the rehabilitation period we are now entering upon and the demand for meat, milk, leather and breeding animals.

On January first Dr. Hallman became connected with the State Agricultural Experimentation staff, his time and salary being adjusted to permit of his devoting 25-27 of his energies to the research problems and 2-27 to teaching general pathology. This is a start in a field offering extensive opportunity for rendering valuable service to the livestock owners of the state; a field having many important phases for research work and animal disease control problems. Michigan with a sum exceeding $200,000,000, invested in its farm animals is essentially a livestock state and it is our desire to so augment the personnel of the Department of Animal Pathology as to facilitate its carrying on a disease control project and as I recently outlined in my annual communication referring to the salary budget for the next fiscal year.

Research work of this character serves not only to improve our knowledge concerning methods for prevention of disease; it educates the people on the economic importance of disease and in this will serve to reduce the present losses; equally so, it adds materially to the quality of student courses in the laboratory work of animal pathology. This work in laboratory diagnosis renders assistance to the practitioner helping to bring him and his profession closer to the college, which he will learn to look upon as a place to obtain assistance, information, technical diagnosis, and advice in treating or controlling disease.

Besides the addition to the division faculty, we have taken on during the year an extra veterinarian, Dr. A. McKercher, practitioner of Lansing, with a view to extending our clinical training for senior students. Each afternoon since January first, two senior students have been assigned to this out-clinic work wherein opportunity has been afforded actual contact experience in general practice. While this temporary arrangement supplied a much needed feature and did strengthen the weakest phase of the course, the arrangement, we believe, was not without its shortcomings and can be much more advantageously developed from viewpoint of its utility to both college and students. As already recommended in my letter concerning personnel we feel a full time veterinarian ought to be retained to develop this out-clinic in cooperation with an internal free clinic and both should be available for educational purposes at all times.

Judge Collingwood as on several previous occasions was prevailed upon

to give a course upon veterinary jurisprudence; the work was characterized by its usual excellence and added materially to the high standard of the veterinary course.

While considering the work of the several departments I cannot emphasize too strongly the fact that, though undertaking to provide an increase in the animal pathology work, there still exists limitation both in its development in that of the department of veterinary anatomy because of inadequate housing facilities. It is one thing to establish and to undertake to develop a veterinary college, to consistently equip the same with apparatus or other working tools, but we must insist withal that a division can be no stronger than the weakest of its component parts; the college is stagnating at this moment for need of a suitable building to house these allied departments.

The division at this writing has as component parts departments of medicine, animal pathology, veterinary anatomy and surgery; we are convinced that for efficient teaching on the related subjects of veterinary physiology, materia medica, poisons and treatment of disease these subjects should be included under the direction of one head, trained in veterinary physiology and the physiologic, toxicologic and therapeutic relations of medical material to animal medicine. To carry this to fruition we recommend creating within the division a department of veterinary physiology and pharmacology and appointment of veterinary physiologist to develop this work. This suggestion like the preceeding is urged at this time because of our knowledge of increasing responsibilities coming to State colleges.

The progress in the science of veterinary medicine has been characterized by a steady demand for an increase of the basic entrance preparation and an increase in the length of the course of study. Though this institution has consistently maintained a fifteen unit entrance requirement and outlined work covering four years, it has been in a class by itself; it is only within the past two years that all veterinary colleges were placed upon a four year basis. Many of the former privately owned veterinary schools forced into a period of depression by this extended course requirements are now obliged to discontinue as a result of the recent war and elevation of entrance requirements as demanded both by the eligibility requirements of the American Veterinary Medical Association; the War Department of the Department of Agriculture; others are seriously considering this step and the State controlled schools will find it incumbent upon them to supply the future essential veterinary material.

At this time it is fitting to make public acknowledgement and expressions of appreciation of the gift of Dr. T. G. Himbaugh, a former graduate of the Agricultural Division of this college, of his entire veterinary library. The volume constitutes a fitting nucleus for a future veterinary library in the veterinary division and one we would suggest be called the Himbaugh Veterinary Library; may hope to see it added to and made available and valuable at all times for student use.

Besides the most efficient and appreciated work incident to training veterinary students, members of the veterinary faculty have engaged themselves with instruction to both groups of short course students in agriculture, to the junior and senior classes in the four year agricultural course; in summer school and one farrier school unit assigned to this institution by the United States War Department for instruction n shoeing an equine anatomy. A second unit was scheduled for November

15th but called off at the time of the armistice. The Department of the division took part in the exhibit prepared during the winter for Farmers' week; have sent representatives to institutes and other gatherings of stock owners, and, as heretofore, continued the rather extensive correspondence with stock owners, county agents and others; a most important and time consuming item but one well worth the attention given it.

In closing permit me to summarize recommendations herein embodied:

1. Engagement of an all time veterinarian to develop and direct an out-clinic for here as with instruction in anatomy and pathology, we must give the men such teaching as to enable them to acquire knowledge of the diseases themselves.
2. The development of a department of veterinary physiology and pharmacology.
3. Addition of an extension man in animal pathology.
4. A sum immediately available of $50,000 for the erection of a laboratory suitable for the relative work of veterinary anatomy and animal pathology.

Respectfully submitted,
RICHARD P. LYMAN,
Dean of Veterinary Medicine.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF ANIMAL PATHOLOGY.

President F. S. Kedzie, College.

Dear Mr. Kedzie—I herewith submit report of the Department of Animal Pathology for the year ending June 30, 1919.

The class work for the following year is as follows:

Pathology 1....Fall term....10 hours week..21 students.
Pathology 2a...Fall term.... 5 hours week..15 students.
Pathology 2b...Spring term.. 4 hours week..15 students.
Pathology 3....Spring term.. 5 hours week..15 students.
Vet. Sci. short course 8 wks....10 hours week..21 students.
Pathology 100 Graduate course, major....... 1 student.

The department was unfortunate in losing the services of Dr. D. J. Lamoureaux whose untimely death occurred February 27th following an attack of influenza. Dr. Lamoureaux was devoting one-half his time to abortion investigations and one half to college work and the loss of his services was keenly felt.

Dr. R. A. Runnells was added to the force January 12th. Dr. Runnells is devoting his entire time to instruction work and the routine examination of tissues in autopsy work, thereby enabling the writer to devote the major part of his time to investigational work. Before Dr. Runnells was added to the staff the writer's time was almost wholly taken up with instruction work and routine laboratory work and very little time was available for investigational work.

However, it is gratifying to note that something has been accomplished with reference to his researches in the nature of treatment in the sterility in cattle. It has been the writer's privilege to meet with groups of veterinarians in various parts of the state during the past year and to lecture and demonstrate the treatment for the sterility in cattle. He has also visited four other states and Canada to meet with their state

veterinary associations to discuss and demonstrate this work. During the past year five manuscripts with reference to *abortion and sterility* have been prepared for publication.

During the year we have performed autopsies on 228 animals. Among these we have recorded the following:

Post mortem	
Intususception of small intestine, horse	1
Traumatic gastritis, cow	1
Traumatic abscess (Hilum of liver), cow	1
Gastro-enteritis, calf	1
Omphalo-phlebitis, calf	1
Acute gastro-intestinal intoxication, calf	2
Strangulated Umbilical hernia, calf	1
Lobar pneumonia, calf	2
Forage poisoning, calf	1
Intestinal helminthiasis, sheep	3
Abscess of medulla, sheep	1
Forage poisoning, sheep	1
Lobar pneumonia, sheep	1
Abscess of cerebrum, sheep	1
Necrobacillosis, lamb	1
Acute enteritis, lamb	1
Diagnosis not made, sheep	1
Intestinal Helminthiasis, hog	3
Pneumonia, hog	6
Acute pericarditis and pleuritis, hog	1
Hog cholera, hog	3
Cirrbosis Edema of lungs, hog	1
Caseous pneumonia, hog	1
Septicemia, hog	2
Acute gastro-intestinal intoxication, hog	4
Diagnosis not made, hog	1
Post mortem	1
Occlusion of bowels, dog	1
Acute stomactitis and pharyngitis, dog	1
Catarrhal gastro-enteritis, acute pancreatitis, dog	1
Canine distemper, dog	1
Uncinariasis, dog	1
Tuberculosis, chicken	20
Dietary trouble, chicken	1
Diphtheria, chicken	6
Alveolar sarcoma (ovary and oviduct), chicken	1
Coccidosis, chicken	8
Ulcerative pharyngitis, chicken	1
Sarcoma (pancreas), chicken	1
Intestinal helminthiasis, chicken	2
Acute hepatitis, chicken	5
Fibrinous peritonitis, chicken	1
Sarcoma (metastatic), chicken	1
Catarrhal enteritis (Guinea hen)	1
White diarrhea, chicken	6
Rupture of oviduct, chicken	1
Bursted egg in oviduct, chicken	1

Sarcoma (kidney and liver) chicken	1
Sarcoma (intestines and ovary) chicken	1
Diagnosis unmade	4
Ruptured stomach, rabbit	1
Coccidiosis, rabbit	2
Mange, Sarcoptic, squirrel	1
Prairie dog, acute indigestion	1

We have received 120 specimens from diseased animals forwarded by veterinarians and farmers. On account of poor packing and improper methods of preparation much of this tissue reaches us in such a condition that a diagnosis cannot be made. Out of this material we have recorded the following cases.

Tissue Examined.

Carcinoma of membrane nictitans, horse	1
Strongylosis, horse	1
Forage poisoning, horse	1
Fibroma, (leg) horse	1
Carcinoma, (tail) horse	1
Chr. myositis, (shoulder) horse	1
Mange, horse	1
Test for hydrocyanic acid, cow, negative	1
Hemorrhagic septicemia, cow, negative	6
Hemorrhagic septicemia, cow, positive	6
Sarcoma of lung, cow	1
Tuberculosis, cow, negative	3
Tuberculosis, cow, positive	1

Tissue Examinations.

Pneumonia, cow	2
Black leg, cow, negative	1
Black leg, cow, positive	1
Suffocation, cow	1
Suppurative mastitis, cow	1
Necrobacillosis, (liver) cow	1
Suppurative dermatitis, cow	1
Actinomycosis, cow	3
Lipo-fibroma, cow	1
Ring worm, cow, negative	1
Ulcerative stomatitis, cow	1
Melano, sarcoma, cow	1
Taeniasis, sheep	1
Nodule disease, sheep	1
Scabies, sheep	1
Intestinal helmithiasis, sheep	1
Tuberculosis, hog	1
Verminous pneumonia, hog	2
Hog cholera, hog, positive	1
Gastritis, hog	1
Pneumonia, hog	3
Fibro-sarcoma, (neck), hog	1
Fibroma, (leg) hog	1
Caseous pneumonia, hog	1

Sarcoma (pleura) hog	1
Nodule disease, hog	1
Rabies, dog, negative	2
Carcinoma, (mammary gland) dog	1
Adeno-carcinoma, (mammary gland) dog	1
Demodex mange, dog, positive	1
Demodex mange, dog, negative	1
Abcess of head, chicken	1
Tuberculosis, chicken	6

Yours very truly,
E. T. HALLMAN,
Professor of Animal Pathology,

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF ANATOMY.

F. S. Kedzie, President, Michigan Agricultural College.

Dear Sir—I herewith submit the fourth annual report of the Department of Anatomy for 1918-19.

As usual the work of the department has been largely that of teaching and while classes have been smaller in numbers they have also entailed greater irregularities, these conditions are largely due to the reaction of our participation in the war especially that of the Student Army Training Corps.

The irregularities caused by men leaving and returning both in the National army and the S. A. T. C. we have gratefully accepted this inconvenience as some of our part in the great war, also as supply instructors in other lines of work due to the absence of Dr. Benner and sickness among the faculty.

The following table is self-explanatory and shows the distribution of instruction only:

Subject.	No. of students.	Credits.	Lectures.	Laborat'y	Total teaching hours.
Summer School, 1918:					
Anatomy 1a	1	4	24	72	96
Anatomy 1b	4	3	12	72	84
Anatomy 1c	1	4	12	108	120
Anatomy 2a	5	4	12	108	120
Anatomy 2b	5	4	12	108	120
6 weeks.					
Horseshoers School, 1918:					
Hippology	25	....	....	24	24
Accompanying detachment to constabulary	25	....	....	24	24
6 weeks.					
Fall Term, 1918:					
Anatomy 1a	9	4	22	66	88
Anatomy 2a	10	4	11	99	110
Anatomy 4	11	3	22	33	55
Surgery 1	18	2	....	44	44
11 weeks.					

Subject.	No. of Students.	Credits.	Lectures.	Laborat'y.	Total teaching hours.
Winter Term, 1919:					
Anatomy 1c	1	4	11	99	110
Anatomy 2a	1	4	11	99	110
Anatomy 1b	8	3	11	66	77
Anatomy 2b	11	4	11	99	110
Anatomy 3a	13	4	22	66	88
Anatomy 2c	4	3	11	66	77
11 weeks.					
Spring Term, 1919:					
Anatomy 1c	8	4	11	99	110
Anatomy 2c	8	3	11	66	77
Anatomy 3b, Sec. 1	2	4	22	66	88
Anatomy 3b, Sec. 2	6	4	22	66	88
11 weeks.					
Grand Total	176	69	270	1,550	1,820

This year two women have taken Anatomy 1a and 1b (Histology). The department approved of opening this course as an elective to the women of the Home Economics Division especially those students planning to go into health work or teaching physiology in the public schools.

Dr. Johnson has utilized most of his forenoons during the winter and spring terms in laboratory technique, making slides for class work. Also Mr. Dwyer has been employed 215 hours on the above work.

Following the trend of veterinary medicine which is now of a more comparative nature, more attention should be given to comparative study. This line of work we have well developed in gross anatomy but not so well in microscopic anatomy since a great amount of time is necessary in making slides of all tissues and organs of all our domestic animals, much time is needed to develop a comparative text covering the microscopic work for the students use.

In former reports attention has been called to the inadequate quarters for housing the anatomy department, the condition still exists while the need is growing upon us, with the evolution of veterinary medicine, more attention being given to the food animals. We find the procuring of dissection material becoming very difficult, thus adequate quarters for a comparative museum for the preservation of permanent dissections and models and storage for dissection material that we may have it when needed and proper room, student and private to carry on the work are essential to the full accomplishment of the anatomy department.

I have called your attention to the efficient manner that Dr. H. E. Johnson has rendered his services to the department and veterinary division in a recent letter on personnel. I recommend that he be retained.

Yours very truly,
F. W. CHAMBERLAIN,
Professor of Anatomy.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF SURGERY AND CLINIC

President Frank S. Kedzie, M. A. C.

Dear Mr. President—I hereby submit my second annual report of th[illegible] Department of Surgery and Clinic for the fiscal year ending June 30, 1919 The recitation and laboratory work has been entirely handled by mysel[illegible] except four laboratory hours in Surgery 1, fall term, which was handle[illegible] by Dr. Chamberlain and Dr. Johnson.

The instruction work for the year is given in the following table.

TEACHING WORK OF DEPARTMENT.

Subject.	Fall Term, 1918			Winter Term, 1919.			Spring Term, 1919.			Summe rSchool, 191[illegible]		
	Recitation hours per week.	Laboratory hours per week.	Number of students.	Recitation hours per week.	Laboratory hours per week.	Number of students.	Recitation hours per week.	Laboratory hours per week.	Number of students.	Recitation hours per week.	Laboratory hour per week.	Number of students.
Surgery 1	4	4	18									
Surgery 2							2		14			
Surgery 3	4	2	18									
Clinic 4a					15	13						
Clinic 4b								15	11			
Clinic 4c		15	18									
Clinic 4d					15	14						
Clinic 4e								15	14			
Surgery 5				3		18						
Surgery 6				4		15						
Horseshoeing, S. A. T. C.										3	4	25
Total	8	21	54	7	30	60	2	30	39	3	4	25

Below is a tabulated report of the surgical clinics for large and small animals treated from October 1, 1918 to June 14, 1919.

Name of disease.	Horses.	Cattle.	Hogs.	Sheep.	Dogs.	Cats.	Poultry.	Rabbits.	Total.
Abortion	1	3							[illegible]
Abscess	9	17			2	1	1		3[illegible]
Arthritis, infectious	3								[illegible]
Amputation of tail					8				[illegible]
Bull-ringing		1							[illegible]
Bone Spavin	14								1[illegible]
Bruised sole	1								[illegible]
Castration, simple	34		1		10	10			5[illegible]
Castrtion, cryptorchid	6								[illegible]
Contusion	7	1		1	2				1[illegible]
Choke	2								[illegible]
Conjunctivitis		1							[illegible]
Coxitis	1								[illegible]
Curb	1								[illegible]
Cervicitis		6							[illegible]
Deoderized		1–	Skunk.						[illegible]
Dystokia	6	16	8	1	2				3[illegible]
Dehorning		48							4[illegible]
Decayed teeth	2								[illegible]

Names of disease.	Horses.	Cattle.	Hogs.	Sheep.	Dogs.	Cats.	Poultry.	Rabbits.	Total.
amination for soundness	4	5							9
r trimming					13				13
amination for pregnancy		2							2
istaxis	1								1
ema of the sheath	1								1
pyema of maxillary sinuses	1								1
cture of the radius	1								1
cture of the femur					1		1		2
tula, sinus	5	1							6
tula, bone		1							1
tula, teat		1							1
nitis	1								1
iter, fibrous	1				1				2
givitis	2								2
g cholera vaccination			236						236
matoma	8	1							9
rnia, umbilical		1							1
rnia, ventral	1								1
p lameness	2	1							3
pertrophy of the membrane nicitans	1				1				2
paction of the crop							2		2
ratitis	2	2			2				6
minitis, chronic	2								2
minitis, acute	3								3
tritis	1	12							13
stitis		31							31
scle atrophy	4								4
il in the foot	12	1							13
vicular lameness	14								14
ariotomy	4				74	15			93
tis					2				2
aritium, interdigital		18							18
vious urachus	3								3
rturient paresis		10							10
ometra		3							3
lapse of uterus		1							1
levil	1								1
taines placenta	2	35							37
gbone	9								9
arer	6								6
inghalt	4								4
atches	11								11
rp and irregular teeth	54								54
rility		4							4
ebone	5								5
icture, teat		6							6
ulder lameness	5								5
amoid lameness	2								2
eeney shoulder	6								6
int	4								4
d crack	1								1
e boil	2								2
don contraction	3								3
oroughpin	14								14
mors, operatable	8	2	2		3				15
mors, inoperatable	3	2			2				7
don rupture	7								7
rush	4								4
th extraction	1								1
dinitis	8								8
ward luxation of the patella	1								1
thral calculi	3								3
ginitis	1	5	2						8
ginal hemorrhage		1							1

Names of disease.	Horses.	Cattle.	Hogs.	Sheep.	Dogs.	Cats.	Poultry.	Rabbits.	Total.
Wound, lacerated	22	10	......	2	3	1	......	......	38
Wound, puncture	17	......	......	......	3	......	......	......	20
Wound, contused	22	3	......	......	2	......	......	......	27
Wound, incised	4	2	......	......	3	1	......	......	10
Wolf-tooth extraction	10	......	......	......	......	......	......	......	10
Total	401	255	249	4	134	28	4	......	1,075

Below is a tabulated report of the medical clinics for large and small animals treated from October 1, 1918 to June 14, 1919

Names of disease.	Horses.	Cattle.	Hogs.	Sheep.	Dogs.	Cats.	Poultry.	Rabbits.	Totals.
Alopecia	......	......	......	......	1	1	......	......	2
Azoturia	35	......	......	......	......	......	......	......	35
Actinomycosis	......	3	......	......	......	......	......	......	3
Acute gastro-intestinal catarrh	2	24	......	......	......	......	......	......	26
Bronchitis	1	3	......	......	2	......	......	......	6
Colic, Tympanic	9	......	......	......	......	......	......	......	9
Colic, impaction	20	......	......	......	......	......	......	......	20
Colic, spasmodic	21	......	......	......	......	......	......	......	21
Colic, intussusception	1	......	......	......	......	......	......	......	1
Constipation	......	......	5	......	8	......	......	......	13
Contagious Rhinitis	......	......	......	......	......	......	......	2	2
Chronic gastro-intestional catarrh	29	......	......	......	......	......	......	......	29
Coccidiosis, intestinal	......	......	......	......	......	......	2	......	2
Chorea	......	......	......	......	2	......	......	......	2
Distemper	......	......	......	......	44	1	......	......	45
Eczema	4	......	......	......	3	......	......	......	7
Enteritis	......	......	1	......	......	......	......	......	1
Forage poisoning	4	10	......	2	......	......	......	......	16
Gastro-intestinal Intoxication	......	......	1	......	......	......	......	......	1
Ging vitis	1	......	......	......	......	......	......	......	1
Gastro-enteritis	......	......	......	......	2	1	......	......	3
Hydrocephalus	2	......	......	......	......	......	......	......	2
Heatstroke	2	......	......	......	......	......	......	......	2
Heaves	3	......	......	......	......	......	......	......	3
Helminthiasis	1	......	10	......	3	......	......	......	14
Impaction of rumen and intestines	......	44	......	......	......	......	......	......	44
Influenza	38	......	......	......	......	......	......	......	38
Lymphangitis	11	......	......	......	......	......	......	......	11
Laryngitis	11	......	......	......	......	......	......	......	11
Lumbar Paralysis	......	......	......	......	1	......	......	......	1
Mange, sarcops	2	......	......	......	......	1	......	......	3
Mange, demodex	......	......	......	......	6	......	......	......	6
Neuritis	......	......	......	......	2	......	......	......	2
Pneumonia	3	7	......	1	2	......	......	......	13
Pharangitis	......	......	......	......	1	......	......	......	1
Purpura Hemorrhagica	1	......	......	......	......	......	......	......	1
Periodic Opthalmia	3	......	......	......	......	......	......	......	3
Polyuria	2	......	......	......	......	......	......	......	2
Phthiriasis	6	4	......	......	......	......	......	......	10
Herpes Tonsurans	......	2	......	......	......	......	......	......	2
Rheumatism	......	1	......	......	......	......	......	......	1
Rhinitis	1	......	......	......	......	......	......	......	1
Strangles	6	......	......	......	......	......	......	......	6
Strychnine Poison	......	......	......	......	1	......	......	......	1
Stomatitis	1	......	......	......	2	......	......	......	3
Stomach Worms	......	......	......	44	......	......	......	......	44

Robert L. Tweed, Private, M. C.

Gerard Dikmans, Private, S. A. T. C.

L. R. Jones, Red Cross and U. S. Public Health Service Extra Contonment Sanitary work.

C. W. Brown resigned to enter practical agriculture and Robert Penner experienced caretaker, died in the spring of 1918, probably of influenza. Also we lost by death from influenza, Dr. D. J. Lamoureaux, who was assisting in the laboratory temporarily on account of the loss of our research men to the army.

Dr. Stafseth, Mr. Cooledge, Mr. Fabian and Mr. Dikman have returned and have resumed their duties. Mr. Nobles returned in January and resigned April first to engage in farming in New York State. We have engaged Robert Snyder, Ph. D., (Cornell) (B. S., M. A. C. '14) to take up the work with nodule-forming bacteria formerly carried on by Mr. Nobles. During the war, Dr. Snyder was in the Medical Corps of the army stationed at the Army Medical School, Washington, D. C., engaged in the manufacture of vaccines for soldiers.

A record of the activities men who served follows:

H. F. Stafseth: Drafted into the national army November 21, 1917; began active service in Supply Company, 329th Field Artillery, November 22, 1917; transferred to Veterinary Corps, 85th Division Headquarters Detachment December 5, 1917; promoted to Sergeant 1st class, March 1, 1918; transferred by own request with Remount Depot No. 320 May 15, 1918; promoted to Second Lieutenant, V. C., July 2, 1918; ordered to duty as assistant veterinarian at A. R. D. No. 320 July 9, 1918; promoted to First Lieutenant September 26, 1918; honorably discharged February 8, 1919.

J. Frank Morgan: Commissioned First Lieutenant S. C., February, 1918; reported to Fort Leavenworth, Kansas and later to Camp Kearney, Cal.; went overseas with the Sanitary Corps in October; attached as instructor to A. E. F. University at Beaune, France; at present casual officer, S. C., St. Argnan, France.

L. H. Cooledge: Enlisted in Medical Department U. S. Army, February 4, 1918; assigned to Base Hospital Laboratory, Camp Greenleaf, Fort Oglethorpe, Ga. for training; ordered to Camp Gordan, Ga., June 1, 1918 for duty with Base Hospital 52; ordered overseas July 1, 1918 with Base Hospital 52; senior non-commissioned officer laboratory, Base Hospital 52 until discharged from service May 14, 1919. Stationed at Rimecourt, Haute Marne, France.

I. F. Huddleson: During October and November 1917 in Red Cross laboratory work at Manhattan, Kansas; in February 1918, enlisted in Sanitary Corps of national army; stationed at Camp Greenleaf, Fort Oglethorpe, Ga., until July when he was commissioned Second Lieutenant, S. C.; transferred to Rockefeller Institute, New York City and then to Camp Crane Allentown, Pennsylvania September 27; went overseas October 27, attached to Evac. Hosp. 37, A. E. F.; after the armistice he was in Coblenz engaged in guarding the water supply; commissioned in 1919, First Lieutenant; still overseas with the army of occupation.

C. G. Nobles: Enlisted in the Sanitary Corps June 1918. Stationed at Camp Leavenworth, Kansas and later at Yale Army Laboratory

School, New Haven, Connecticut; commissioned Second Lieutenant November 1918; discharged from service January, 1919.

F. W. Fabian: Commissioned Second Lieutenant, Sanitary Corps, September 12, 1918; reported for duty at Yale Army Laboratory School, New Haven, Connecticut, September 22, 1918; on duty at Yale Army Laboratory School, New Haven, Connecticut from September 22 to November 12, 1918; ordered to Camp Crane, November 12, 1918; on duty Camp Crane, Allentown, Pennsylvania, from November 12 to December 18, 1918; discharged from service December 18, 1918.

Robert L. Tweed: Enlisted in Medical Corps December 1917; stationed at Camp Lewis, Washington, D. C.; attended Officer's Training School but discharged for physical disability; now in Department of Publicity, Surgeon's Office, Washington, D. C.

Gerard Dikmans: Enlisted in the M. E. R. C. December 22, 1917; remained on in active duty until October 10, 1918; transferred to S. A. T. C. on October10, 1918; discharged on December 21, 1918.

We who were not fortunate enough to get into the big work at or near the front played our little part at home. Miss Northrup, Mr. Reuhle and Dr. Hallman maintained the research problems unselfishly and productively and they were always alert to turn from their investigations to assist in the matters of current and immediate need. Mr. Mallman did double service in maintaining the laboratory courses and in otherwise making the absence of his associates less destructive to the departmental program. During the summer and fall terms we had with us Lieutenant S. N. Lord, three years with the Canadian army in France and in British Hospitals. He assisted greatly in maintaining the courses in pathogenic bacteriology and also in the supervision of a diagnostic laboratory for the S. A. T. C. during the influenza epidemic of the fall term. During this epidemic, we virtually turned our resourses over to the army medical department, supplying hospital facilities to our limited ability, laboratory diagnostics and mortuary.

We also participated in the instructional work of the S. A. T. C. teaching Military Hygiene. In spite of the great drain made upon our student body by war activities, our force of instructors was kept more than busy. The following is a summary of the number of students taking the various courses:

Summer Term 1918..

Bacteriology 1	Ward Giltner	13	students.
Bacteriology 1b	Ward Giltner	1	"
Bacteriology 2	W. L. Mallmann	15	"
Bacteriology 3	Zae Northrup	7	"
Bacteriology 4	Zae Northrup	1	"
Bacteriology 13	Ward Giltner	3	"
Bacteriology 14	Ward Giltner	5	"
Bacteriology 19	S. N. Lord	14	"
Bacteriology 102	Zae Northrup	1	"
Bacteriology 103	Zae Northrup	1	"
Bacteriology 105	E. T. Hallman	1	"

Fall Term 1918.

S. A. T. C. Military Hygiene	Ward Giltner	173	"
Bacteriology 1	Ward Giltner	69	"
Bacteriology 1a	Ward Giltner	12	"
Bacteriology 2	W. L. Mallmann	16	"

Bacteriology 3	R. P. Hibbard	28	"
Bacteriology 4	W. L. Mallmann	8	"
Bacteriology 13	Ward Giltner	6	"
Bacteriology 14	Ward Giltner	1	"
Bacteriology 19	S. N. Lord	10	"
Bacteriology 102	Zae Northrup	1	"

Winter Term 1919.

Bacteriology 1a	Ward Giltner	45	students.
Bacteriology 1b	Ward Giltner	35	"
Bacteriology 2	W. L. Mallmann	80	"
Bacteriology 3	F. W. Fabian	15	"
Bacteriology 4	W. L. Mallmann	15	"
Bacteriology 13	Ward Giltner	19	"
Bacteriology 17	F. W. Fabian	5	"
Bacteriology 19	F. W. Fabian	5	"
Bacteriology 23	W. L. Mallmann	3	"
Bacteriology 102	Zae Northrup	1	"
Bacteriology 105	F. W. Fabian	2	"
Bacteriology 106	Zae Northrup	1	"

Spring Term 1919.

Bacteriology 1b	Ward Giltner	25	students.
Bacteriology 1c	Ward Giltner	60	"
Bacteriology 2	W. L. Mallmann	10	"
Bacteriology 3	F. W. Fabian	16	"
Bacteriology 4	F. W. Fabian	5	"
Bacteriology 14	Ward Giltner	33	"
Bacteriology 15	Ward Giltner	7	"
Bacteriology 17	G. L. Ruehle	15	"
Bacteriology 19	H. J. Stafseth	17	"
Bacteriology 102	Zae Northrup	1	"

The student health situation has not assumed a more satisfactory condition during the past year, either as regards a system of student health control or as regards our freedom from disease. The Influenza epidemic is something we might not have avoided even with the best system. That, of course, is debatable, but there can be no question about the fact that we lack a good system of student health control.

On January 17th, I received from your office the following:

"MEMORANDUM OF AGREEMENT RESPECTING THE FUTURE ADMINISTRATION OF THE COLLEGE HOSPITALS.

"1. On advise and recommendation of Dr. Giltner and acquiesced in by all concerned, Dr. O. H. Bruegel, Health Officer of East Lansing, has been appointed Medical Officer for M. A. C. at an annual salary of $1,200 for services embracing the calendar year ending September 1, 1919 and to be renewed thereafter in a manner similar to the renewal of contracts with other officials and employees of the college staff. Dr. Bruegel's services embrace the following:

"a. He is to diagnose all cases of illness among college students to which he is called and to determine upon their removal to the hospital.

"b. He is to be the Medical Superintendent of the college hospitals and unless another physician is requested by the patient, it is understood that Dr. Bruegel will be in charge of the case. His services, however as

such physician are to be paid for by the patient in addition to the hospital charge referred to in another paragraph. The collection of this physician's charge will not be undertaken by the college.

"c. Dr. Bruegel as Medical Officer of M. A. C. will assist where needed in the physical examination of all male students without additional remuneration. (?)

"d. Dr. Bruegel, consulting with the President will employ and discharge all nurses needed for the hospitals.

HOSPITAL MANAGEMENT.

"1. As heretofore, the general care of the hospitals is placed in charge of Dr. Giltner as head of the Department of Bacteriology and Hygiene. All necessary supplies are to be obtained by the usual requisition issued through his office. This includes material of every kind and nature for the maintenance of the hospitals.

"2. All necessary accounts including (a) time and pay roll of nurses, (b) date of admissions and discharge of patients, (c) bills for hospital services given patients shall be handled in Dr. Giltner's office and shall be transmitted to the Secretary's office for collection at proper intervals. It is understood that immediately upon the discharge of a patient from the hospital, the Secretary's office shall be notified so that means for the collection of hospital fees may be taken. The charge for hospital attendance in ordinary cases which includes nurse's attendance, food, etc., shall be ten dollars ($10.00) per week per patient."

In spite of an effort to carry on matters under the direction of this memorandum, I fail to find in the college catalogue for the ensuing year any mention made of student health supervision. It seems to me that this is very unfortunate and leaves the college authorities open to severe criticism.

After consulting with Professor Brewer of the Department of Physical Education the following recommendations were drawn up by Professor Brewer for a health service for the Michigan Agricultural College:

I. Adminstration.
   a. Creation of a committee to formulate and carry our policies, this committee to consist of: (1) Professor of Department of Bacteriology, Hygiene, and Pathology, (2) College Physician, (3) Dean of Women, (4) Director of the Department of Physical Training, (5) A fifth member appointed by the president.
   b. A small fee of fifty cents or one dollar per term to be collected from each student and to be known as "Health Service Fee".
   c. A fee card issued to each student entitling him to free medical advice, hospital service, and medical service, except for major operations and major illness, while he is a student.
   d. Employment of a trained man to be known as "College Physician"

II. Activities and Responsibilities.
   a. Physical and medical examination of every student as soon as possible after entrance.
   b. Re-examination as often and as many times as seems best for all "Correction Cases", as indicated by first examination.

c. One or two hours each day when "College Physician" will be in physicians office in gymnasium for purpose of giving free medical advice to any student. Some arrangement for regular time in women's building.

d. A graduate nurse in connection with college hospital, who will give free medical advice or help to any student at any time.

e. Compulsory medical attention. (A student not able to attend classes automatically and immediately comes under authority of "College Physician" and "Health Service Committee").

f. Authority to prescribe physical training work for one, two, three or four years as particular individuals or groups show need.

g. Compulsory corrective work by Department of Physical Training for all "correction cases".

h. A series of lectures on general health, health education, exercise, public and personal hygiene, etc., to be given to all freshmen during the first two terms, these lectures to be given jointly by the Department of Bacteriology and Hygiene and the Department of Physical Training.

i. Responsibility for ventilation, sanitation, general hygienic conditions of all class rooms, buildings, laboratories, shops, dormitories, boarding clubs, kitchens, (including help), on college grounds.

j. Authority over living conditions of all students on or off campus.

k. Authority in case of epidemics, contagious diseases, etc., both as to individuals and the college community as a whole.

l. Authority to remove from the institution or prohibit from the use of any utility facility, of privilege such as boarding clubs, toilets, gymnasium, etc. of any individual with venereal disease or infectious disease, dangerous to the student body.

m. Authority over anything that may come up from time to time in case of the individual student, a group, or the college as a whole, that has to do with the health or health education either of the individual or the group or the college.

These recommendations with or without modifications as the policies of the college may demand meet with my approval and I recommend that they be adopted and put into force at the earliest possible date.

The number of cases that have been handled in the college hospitals during the past year and the financial report covering hospital activities follows:

Diseases	*No. of cases*	*Deaths*
Small Pox	2	
Chicken Pox	2	
Severe Cold	6	
Injury and Infection	11	
Mumps	6	
Tonsilitis	7	
Measles	2	
Rheumatism	3	
Observation	6	
Pneumonia	4	1
Influenza	120	2

FINANCIAL REPORT.

O. H. Bruegel	$ 874.00
Nurses	4,303.96
Sundry items	2,408.04
Total expenditures	$ 7,586.00
Total expenditures	$ 7,586.00
Hospital receipts	$ 1,510.67
Deficit	$ 6,075.33

Throughout the year, tests were made by Mr. Mallman upon the water of the college swimming pool at intervals of three days. The increase of bacteria has always been very rapid notwithstanding the fact that the water was filtered for at least 12 hours every day. Apparently, the filter has not been working efficiently. Work is now being carried on to find the cause of the trouble.

In conclusion I wish to recommend very highly the efficient and energetic services of Mr. Fabian and Mr. Mallman in charge of the student laboratories and to express my appreciation of the valuable assistance rendered by Mr. Reuhle in taking full charge of classes in dairy bacteriology andby Miss Northrup who has always been in readiness to fill a vacancy in the class room. Dr. Stafseth has rendered noteworthy service in the classes studying pathogenic bacteriology and immunology. Mr. Lutz and Mr. Klever have beenvery faithful in caring for the stock room and the building and equipment.

Respectfully,
WARD GILTNER,
Professor of Bacteriology and Hygiene.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF BOTANY.

President F. S. Kedzie, College.

Dear President Kedzie—I have the honor to make the following report for the Botanical Department for the fiscal year ending June 30, 1919.

Owing to conditions resultant from the war, the botanical staff for the past year has been smaller than in the preceding years. Mr. Harry C. Young was transferred to the Experiment Station staff beginning July 1, 1918. Graduate Assistants C. W. Bennett and C. F. Murphy were both on leave of absence for military service, at the beginning of the fiscal year. Mr. Bennett was discharged from the army in December and returned to the College on January 1st. Mr. Murphy did not receive his discharge until April and found it necessary to resign in order to accept a position in the U. S. Department of Agriculture.

The department and the College suffered a great loss by the death of Miss Rose M. Taylor on December 5th after a very short illness from Influenza. Miss Taylor began service in the department at the beginning of the winter term in 1909, and had thus completed all but a few weeks of 10 years of service. She was always an exceedingly able instructor who obtained the best from every student. Her training was excellent and she

continued her studies while connected with the College, so that she was entrusted with the course in Forest Pathology and some other courses, conducting the work with great credit to the institution.

The two Graduate Assistants who were absent on military service remained in training camps in this country during their entire service. Mr. Bennett was at Fort Adams for several months, and then was sent to the Officer's Training Camp for coast artillery at Fortress Monroe, from which he was discharged after the signing of the armistice, about four weeks before his commission was due.

Mr. Murphy was for practically his whole period of service at Camp Lee, Petersburg, Virginia, at which camp he quickly became Regimental Sergeant Major in the Personnel Division, having charge of a large amount of the trade test work.

During the period of the Student Army Training Camp, the following members of this department were employed in teaching in other departments:

E. A. Bessey had charge of two quiz sections in War Aims.

Professor R. de Zeeuw gave his full time to assisting in laboratory work and in charge of quiz sections in Physics.

Dr. R. P. Hibbard had charge of Bacteriology 3 in the fall term and assisted for seven hours a week with a class in Meteorology.

Professor H. T. Darlington devoted nearly his full time to teaching Mathematics, only a small portion of his time being available for botanical garden and herbarium work.

Professor E. F. Woodcock devoted his full time to physics quiz and laboratory sections.

This loaning of members of the Botanical Department to other departments was made possible without impairing the efficiency of the botanical work by the small number of students taking botany during the fall term.

During the past fiscal year, Dr. G. H. Coons and I attended the meetings of the national scientific societies at Baltimore during Christmas week, (American Association for the Advancement of Science, Botanical Society of America, American Phytopathological Society, etc.) At the close of March the department was represented by myself, Dr. G. H. Coons, Dr. R. P. Hibbard and Professor H. T. Darlington at the meetings of the Michigan Academy of Science and the Schoolmasters' Club, where papers were read which will appear in the forthcoming report of the Michigan Academy of Science.

During the summer of 1918, Professor Darlington and I made a collecting trip to Alpena and vicinity and points along the west shore of Lake Huron as far south as Tawas City. Some interesting plants were found, one of which had not been reported before except on Isle Royal in Lake Superior. By means of these collecting trips the distribution and habits of the plants of the state are becoming much better known and it is hoped that only a year or two more will be needed to enable us to publish the Flora of Michigan on which we have been working for the past six or more years.

Professor Darlington has completed and has ready for publication a paper on the distribution of the Orchids in Michigan.

The Botanical Garden has continued to be a point of great attraction for visitors coming to the campus. In order to make it as instructive as possible, we are gradually adding a series of descriptive labels. The

garden could be much more efficiently managed if it were possible to have a larger greenhouse, especially for starting plants in the early spring and for over-wintering tender sorts.

Although reduced in numbers on account of the war, the Botanical Seminar has continued very actively at work. Two public addresses were given the past year under its auspices, viz.: in the autumn by Dr. E. C. Stakman, Professor of Plant Pathology, University of Minnesota, on "Biologic Forms of Cereal Rusts," and in May by Professor H. H. Bartlett of the Department of Botany, University of Michigan on "The Village and Jungle Life of the Sumatran Batak". Both lectures were intensely interesting.

Respectfully submitted,
E. A. BESSEY,
Professor of Botany.

East Lansing, June 30, 1919.

REPORT OF THE SEED LABORATORY.

Mr. A. M. Brown, Secretary, State Board of Agriculture, East Lansing, Michigan.

Dear Sir—I transmit herewith the report of Miss B. A. Hollister, Seed Analyst.

Respectfully,
E. A. BESSEY,
Professor of Botany.

Dr. E. A. Bessey, East Lansing, Michigan.

Dear Sir:—I have the honor to present to you, the report of the work of the Seed Laboratory for the year ending June 30, 1919.

Yours very truly,
B. A. HOLLISTER,
State Seed Analyst.

The work of the seed laboratory was carried on as usual during the past year, in spite of the unsettled conditions due to the epidemic of influenza and the readjustment resulting from the signing of the armistice.

Shipments of seed coming into the State from other states have caused us a great deal of trouble. This is true of other states as well, and a movement has been started to get a federal law which will take care of interstate shipments. At present nothing can be done in this State, and not very much in other states. Three or four firms have been the offenders, and have succeeded in placing in this State a large quantity of very poor seed. A great many samples were sent to the seed laboratory and all of these seemed to be from the same lot of seed. This applies only to samples of seed from the firms in question. Samples from other dealers were largely up to standard. It would be very desirable if farmers could be urged to buy seed either of their local dealer or from any other firms which are known to be reliable. Many of them buy from mail order houses and neglect to send a sample for analysis, thus filling some of their fields with a great uantity of weeds, some of which are not only undesirable but very noxious.

In connection with the foregoing I might suggest that it is unfortunate that we are unable to send men out to inspect seed at the time when most of it is being sold at retail. This would help to eliminate some of the poor lots of seed which are sent into the State.

I made a trip to Detroit in May to look up the matter of lawn grass mixtures. A great deal of this seed is sold by grocers and hardware merchants, practically none of whom know that we have a seed law. All of them are anxious to comply with the law and promptly labelled what seed they had on hand, when they received the analysis. A good deal of this trouble might be eliminated if the wholesaler would place the proper label upon the packages.

The Publicity Department of the College has been of great assistance in obtaining publication of news items from the laboratory.

Owing to the great increase in wages, cost of supplies, etc., the small appropriation for the maintenance of the Seed Inspection work does not suffice to employ sufficient additional help during the rush season, January to March inclusive, to permit of having inspectors send in large numbers of seed samples. Perhaps, therefore, it is fortunate, in a way, that the money does not suffice to hire seed inspectors. It is doubly to be regretted that the fees hitherto available for the work of the Seed Laboratory must henceforward be turned in to the State Treasury.

The time is now ripe it seems, for a revision of the present seed law to conform with the ideas exhibited in the "Model Seed Law" recommended jointly by the Association of American Seed Analysts and the American Seed Trade Association after a study for several years in committee and open meeting. Given such a law and funds sufficient to employ two or more analysts and several inspectors, it would be possible to prevent the fraudulent sale of most poor seed.

B. A. HOLLISTER,
State Seed Analyst.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the following report on the work of the Department of Chemistry for the year ending June 30, 1919.

The teaching staff of the year was as follows:

A. J. Clark, Professor.
H. S. Reed, Associate Professor.
B. E. Hartsuch, Assistant Professor.
*D. T. Ewing, Assistant Professor.
E. H. Doherty, Assistant Professor.
H. L. Publow, Instructor.
P. S. Brundage, Instruction.
E. F. Eldridge, Instructor.
H. C. Lange, Instructor.
H. A. Iddles, Instructor.
R. H. Cromley, Instructor.
Harold R. Laing, S. A. T. C. Assistant.
Mabel Mosher (Winter Term only)
Associate Professor, R. C. Huston returned April 1st, for spring term.
Instructor C. D. Ball, Jr., returned April 1st, for spring term.
Instructor B. E. L. French returned April 1st, for spring term.

The work of the year has been very unsatisfactory in some ways and entirely satisfactory in others. The many interruptions during the fall

* At Chicago University on leave of absence.

term while we had 521 students enrolled in the various courses were very discouraging. The return to more nearly normal conditions during the spring term, however, has been very gratifying and the teaching staff of the department is looking forward with enthusiasm to the coming year.

Thirty-five courses have been offered during the past year, practically all of the courses requiring laboratory work as well as recitations or lectures. The number of students enrolled in these courses during the year was as follows:

Summer Session 1918	54
Fall Term 1918	521
Winter Term 1919	486
Spring Term 1919	400
	1461

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The equipment in our industrial chemistry laboratory nas been installed and will be in use during the present summer session. In this laboratory I believe we have a valuable asset to the institution and to the industries of the State.

The official record of the members of the staff absent during the year n service is as follows:

1. Chas. Dodson Ball, Jr., enlisted State College, Pa. Aug. 2, 1917; assigned to Ordnance Dept., Sept. 14, 1917 at Watervliet Arsenal, N. Y.; sailed for France, Jan. 4, 1918; transferred to Chemical Warfare Service, April 11, 1918 and stationed in laboratories at Puteaux, near Paris; discharged, Feb. 10, 1919.

2. Beals E. L. French entered service, March 15, 1918; assigned to duty with Co. F, 302 Engineers at Camp Upton, Me.; sailed for France in April 1918; transferred to 306 Field Hospital, 77 Division; transferred to Chemical Warfare Service, October 1918; discharged Camp Upton, Feb. 3, 1919.

3. Howard D. Lightbody entered service, April 3, 1918 at Chicago and assigned to Fort Preble, Me., to 6th Recruit Co., and later to Battery E, 72nd C. A. C.; transferred to Chemical Warfare Service, July 25, 1918; assigned to Research Battalion, American University, Washington; embarked for France Sept. 19, 1918 from Camp Merritt on U. S. S. America; disembarked at Brest, Sept. 29, 1918; entrained for Chaumont; assigned as Field Chemist to Headquarters, 2nd Army Corp and joined this organization October 10, in area between Ammen and Albert; March 25, 1919 reassigned to Fourth Army Corps in Army of Occupation; May 2, 1919 left Germany for Brest, France having been reassigned to the 33rd Division; May 10, 1919 embarked for New York on U. S. S. Mount Vernon; May 19, 1919 disembarked and sent to Camp Mills, L. I.; May 30, 1919 discharged at Camp Grant, Ill.

4. Ralph Chase Huston, Captain Sanitary Corps, Laboratory Div. Commissioned Aug. 6, 1918; assigned to Rockefeller Institute; assigned to Yale University Sept. 20; assigned to Camp Polk, Dec. 25, 1918; assigned to U. S. General Hospital No. 19, Oteen, N. C.; Discharged Feb. 1, 1919.

During S. A. T. C. regime A. J. Clark was acting Field Director of American Red Cross.

Respectfully submitted,
ARTHUR J. CLARK,
Professor of Chemistry

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit for your consideration the following report on the work of the Department of Mathematics for the year ending June 30, 1919:

During the year the teaching staff of the department was as follows:

L. C. Plant, Professor.
L. C. Emmons, Associate Professor.
M. F. Johnson, G. G. Speeker, and S. E. Crowe, Assistant Professors.
W. M. Wibble, *Instructor.*

During the fall term Professors E. S. King, H. T. Darlington, W. E. Reuling and F. A. Burt and Mr. B. K. Philp taught classes in the Student Army Training Corps.

At the opening of the fall term an unusual demand was made on the department both for instruction and for subject matter. The former was met by other departments' coming to our assistance. Professor King, of the English Department, Professor Darlington, of the Botany Department, Professor Reuling, of the Mechanical Engineering Department, Professor Burt of the Geology Department, and Mr. Philp, of the Civil Engineering Department offered their help. I take this opportunity to thank these men for their assistance and to say that notwithstanding the fact that they were teaching outside their chosen fields, no more enthusiastic body of teachers could have been found on the campus.

Our national Government asked that the Student Army Training Corps be taught mathematics that should be adapted so far as possible to special phases of army work. Professor W. Paul Webber, of the University of Pittsburgh, and myself had a manuscript on Introductory Mathematical Analysis which seemed to meet more nearly the requirements of the Government than any text on the market. By putting forth every effort and by the cooperation of John Wiley and Sons we were able to place in the hands of the students preprints of the text soon after the opening of the term. The completed text was off the press in January. The government inspector of work done in the S. A. T. C. units in different educa- ;erent institutions, Professor S. E. Stout, of the University of Indiana, was so well pleased with our mathematics that he asked for a detailed outline of the same in order that he might present copies to other institutions.

The success of the department is largely due to the personal interest of the members of the staff. They have given generously of their time out of class hours to their students and they have used their spare time and vacation periods in doing graduate work.

The total number of students taking mathematics during the year was 1,219, divided among the different terms as follows: fall, 417 S. A. T. C. students, 147 regular students; winter, 302; spring, 257; summer, 96. The total number of class periods for the year was 367, divided among the different terms as follows: fall, 125; winter, 98; spring, 74; summer, 70.

Respectfully submitted,
L. C. PLANT,
Professor of Mathematics.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY.

To the President.

Sir—I have the honor to submit the following report of the Department of Zoology and Physiology for the year ending June 30, 1919:

Except for the interruption and changes due to the Students Army Training Corps and related activities the work of the Zoological Department has progressed almost as usual during the past year. Instructor Bergquist who enlisted in March 1918 is still on leave and with the 20th Engineers abroad. With this exception there have been no changes in the personnel of the department.

In the fall term assistant professors, Roseboom and Burt were assigned respectively to the Chemical and Mathematics Departments, the former giving his entire time to the teaching of physiological chemistry and the latter teaching three five-hour courses in algebra and trigonometry. Instructor Stack became an assistant in the Bacteriological laboratory for the whole term and Assistant Professor Conger gave part of his time to the teaching of "War Aims" under the Department of History and Political Science. Classes in beginning zoology and advanced physiology for the women, and elementary zoology for veterinary students, were the only subjects handled in our own department.

In the winter term Professor Roseboom continued to give all his time to physiological chemistry and Mr. Stack to give half his time to bacteriology. Professor Burt had two required classes and one elective in geology, Mr. Conger and the writer gave the classes in zoology, and Mr. LeRoy and Mr. Stack cared for the veterinary physiology and the beginning physiology for one half of the freshmen women.

The spring term was practically normal, the return of many of the young men who had been in the service bringing the elective classes nearly to full size.

The department's share in the Summer School was not large. It consisted of a two-weeks course in bird-study given to seven students (mainly teachers) by the writer, and six-weeks courses in elementary zoology and elementary physiology by Mr. Roseboom to seven other students.

Several important changes in courses of study made during the past year have affected rather seriously the balance of work in this department. The transfer of the required physiology for women from the freshman to the junior year will leave the department without any of this work for two years to come, and the dropping of elementary zoology from the women's curriculum still further reduces the hours of work of our teaching staff. It is to be regretted that such radical changes cannot be foreseen far enough in advance to allow intra-department adjustments which would prevent overwork in some terms and semi-idleness in others.

As usual the department has complied occasionally during the year with requests for lectures or talks before schools and societies of various kinds and is prepared to do more of this work in the future. In this connection it may be noted that Professor Conger has in preparation a popular bulletin on the haired animals of the State, with special reference to those which affect agriculture in any way, with directions for the extermination or control of injurious forms.

In response to the government's call for the loan of field-glasses to serve as "Eyes for the Navy" the department sent Assistant Secretary

Roosevelt a description of the 18 pairs of glasses used in our bird work and from these ten pairs were selected and forwarded in April, 1918. Soon after the armistice was signed one pair of glasses was returned, followed at intervals by others until on June 21st the last glass had been returned, all in perfect condition, and with an engraved certificate of thanks and appreciation from the Assistant Secretary of the Navy.

MUSEUM.

During the fall term the lack of regular teaching enabled the curator and other members of the department to devote more attention to the General Museum than has been possible in any one term for many years past. As a result its general condition has been very greatly improved. The entire display of minerals and fossils has been rearranged, the large collection of marine invertebrates from J. M. Knapp (with '61), from the Puget Sound region, has been displayed and properly labeled, and a large part of the Harry K. Pomeroy collection of birds eggs has been put on exhibition, although as yet it lacks printed labels. In addition the entire collection of birds, both on the museum shelves and in storage, has been overhauled and the museum part has been considerably augmented and improved. In the course of this work it was found possible to remount some two hundred specimens from the Broas collection and these were used freely for the classes in ornithology during the spring term. Much remains to be done along this line and in particular the museum needs the addition of good specimens of many common reptiles, fishes, birds and mammals which are not now represented at all.

Respectfully,
WALTER B. BARROWS,
Professor of Zoology and Physiology
and Curator of General Museum.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

President F. S. Kedzie.

Dear Sir—Following is a brief report of the work of the Department of Entomology for the year ending June 30, 1919.

During the year the following courses were given by the department:

Summer Term, 1918.

Two weeks course in nature study.
R. H. Pettit and Miss McDaniel.

Fall Term.

Ent. III. Insect pests of field crops.
R. H. Pettit.

Ent. VIII. Parasitology for veterinary students in S. A. T. C.
Dr. Chandler and Miss McDaniel.

Winter Term.

Ent. IV. Forest Insects.
R. H. Pettit.

Ent. XI. Household insects for women.
R. H. Pettit and Miss McDaniel.

Ent. Va and b. Applied Entomology.
Miss McDaniel.

Ent. Xe. Apiculture (option).
Mr. B. F. Kindig.

Besides these a short course was given in fruit-insects and one in apiculture to horticultural students, by R. H. Pettit and Mr. Kindig; one to men in general agriculture, second year, on field crop pests, by R. H. Pettit; one on garden insects, by R. H. Pettit; and a short course of one week known as "bee-week", for apiculturists, by Mr. Kindig.

Spring Term.

Ent. I. Introductory Entomology.
R. H. Pettit and Miss McDaniel.

Ent. II. Fruit insects.
R. H. Pettit.

Ent. V. Applied Entomology.
Miss McDaniel.

Ent. Xa. Beginning of the option in Apiculture and
Xd final term in Apicultural option andboth by Mr. Kindig.

During the epidemic of Spanish Influenza last fall, a very interesting and effective campaign against house-flies was carried on by the department under the direction of Doctor Chandler. During this campaign the attempt was made to kill by formaldehyde, as many flies as possible in the mess-halls, in the hospital wards, in isolation hospitals; and, by poisons and sprays, in their breeding places—the most notable being the piggery. It was comforting to note that the number of new cases dropped in a very gratifying manner immediately (that is the day after) operations were instituted, and so great a proportion of our supply of flies was destroyed that up to the middle of the following June (1919) the comparative absence of flies was noticeable.

Mr. Don B. Whelen, Extension Specialist in Insect Control, has resigned to take up work in the commercial field, his resignation taking effect on June 30th. Mr. Whelen was, at the time of leaving, engaged in directing a general campaign against grasshoppers in Antrim, Benzie, Charlevoix, Cheboygan, Crawford, Emmet, Grand Traverse, Kalkaska, Manistee, Missaukee and Roscommon counties, where grasshoppers have destroyed a great deal of wealth in the form of crops for two or three years past.

Mr. Edwin Ewell, Extension Specialist in Apiculture, has carried information of great value to the apiculturists and has, during the year, organized the beekeepers into country clubs, in 14 counties.

Our practice of answering queries by correspondence seems to be appreciated by the people of the State. During the month of June besides a large mass of routine mail to companies and individuals, the writer replied to 72 letters from county agents in reply to requests for expert advice.

The last legislature increased the appropriation for State Apiary Inspection from $3,000 to $10,000, thus making it possible to increase the quantity of work done. Further information will be supplied in the report of the State Inspector of Apiaries.

Respectfully submitted,
R. H. PETTIT,
Professor of Entomology.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF PHYSICS.

President F. S. Kedzie, College.

Dear Sir—The following is a brief record of the activities of the Physics Department for the school year ending June 30, 1919.

Due to the fact that both the regular and S. A. T. C. work in physics were given simultaneously during the fall term, it became necessary to enlarge our lecture room facilities. The northwest corner room on the first floor of the Forestry Building, formerly used by the Home Economics Department as a laboratory, was converted into a very satisfactory auxiliary lecture room.

A self ventilating storage battery room was built in the agricultural physics laboratory. This has meant much to the department by eliminating the acid fumes which heretofore permeated the building, thereby corroding delicate and expensive apparatus.

A unique switchboard was designed, built and installed by Professor Armstrong for the distribution of low voltages (8, 16, 32 and 64 volts) to lecture rooms and laboratories. This enables us to draw as high as 400 to 600 amperes direct current for lecture table demonstration purposes, as well as giving constant voltages for laboratory work.

The rebuilding of an old rotary converter of 2 K. W. capacity has made it possible for us to obtain alternating current for lecture and laboratory uses.

During the Summer School of 1918 the following courses in physics were given: 1d, 1e; 2d, 2f; 4b; also a course in High School physics. This work was presented largely from the laboratory rather than the usual lecture, quiz and laboratory standpoint, which allowed a greater amount of personal work as the classes were small.

Since the equipment of the Physics Department was well suited for presenting the starting, lighting and ignition work given to the Motor Mechanics, our lecture room and apparatus were used by them during the summer and fall terms.

The work of the fall term was quite out of the ordinary. School began October 1st with the S. A. T. C. program not clearly defined. A tentative program outlined by a committee of the faculty was supplanted by a course of study prepared by the Committee on Education and Special Training, Washington, D. C.

The total number of men enrolled in the war courses in physics was 201. These were either 19 or 20 year men who had chosen some one of the following groups the of service.

19 YEAR MEN.

(a) Infantry and Artillery.
(b) Air Service.
(c) Chemical.
(d) Transport and Tank.

20 YEAR MEN.

(a) Air Service.
(b) Ordnance.
(c) Engineer Corps.
(d) Chemical.

Since these various groups came at different periods of the day, additional teaching help was required to handle these war courses efficiently. To meet this need the Botany Department very kindly offered to the Physics Department the full time services of Dr. Woodcock and Dr. De-Zeeuw. This offer was accepted. At the same time we also gave the regular courses, Physics 1d and Physics 2d, all of which made for us an exceptionally heavy schedule of work.

The department made a still further contribution to the war program of the College. At the request of Captain Henderson and Lieutenant Bridgman of the Infirmary, it did skiagraphic X-Ray work for the several detachments, with apparatus made and assembled in the department except for a discarded hydrogen X-Ray tube.

At the beginning of the winter term it was found expedient to repeat the usual fall term's work in addition to the regular winter term's work to be given, in order that the students then entering college would be able to finish their regularly scheduled work at the end of the Summer School thus permitting them to graduate with their respective classes.

During the spring term it also became necessary for the same reason to give both the winter and spring terms' work simultaneously.

On September 1st the Physics Department sustained a great loss in the resignation of one of its members, Professor O. L. Snow, who had rendered very faithful and efficient service for eight years. Mr. Snow left to accept a position with the United Engine Company, Lansing, Mich., to which was attached a salary of nearly double that which he received from the college.

Mr. E. A. Armstrong, an M. A. C. graduate of the Class of 1911, Electrical Engineering Course, was hired to fill the position made vacant by the resignation of Prof. Snow. He in turn resigned at the end of the winter term to accept a more lucrative position with the National Machine Products Company of Detroit, Michigan.

No one was secured to fill the position vacated by Prof. Armstrong. The part time services of Assistant Prof. P. G. Andres were loaned to the Physics Department by the Department of Electrical Engineering, to handle the engineering physics courses, Physics 2e and 2f, previously taught by Professor Armstrong. He was assisted in this work by Mr. R. J. Bondie of the class of 1918.

Due to the conflicts in schedules caused by the doubling of the work, we were obliged to employ student laboratory asisstants for part of the work throughout both the winter and spring terms.

The number of students per term enrolled in physics was as follows:

Summer School, 1918	18
Fall Term, 1918—	
S. A. T. C. Students	201
Regular Students	11
Total	212
Winter Term, 1919	179
Spring Term, 1919	173
Total for the year	564

Aside from the assistance rendered the department by Dr. Woodcock and Dr. de Zeeuw; that of Assistant Professor Andres; and that of the

laboratory assistants previously mentioned, the departmental work was cared for by Associate Professor Laycock, Assistant Professor E. A. Armstrong and myself. Assistant Professor Snow assisted with the work of the summer school.

Mr. Ralph M. Harford's name was added to the regular College payroll, July 1, 1918, as College Photographer.

I wish to take this opportunity to thank the Botany Department for the loan of Dr. Woodcock and Dr. de Zeeuw during the period of the S. A. T. C., also the Department of Electrical Engineering for the loan of Mr. Andres for part time during the spring term.

In compliance with repeated requests, the faculty at its meeting, March 17th, authorized the Physics Department to give three courses in physics, namely: Physics 100, 101 and 102, as minors in the graduate school. These added courses will make us feel keenly the shortage of available laboratory and lecture room space.

Considerable difficulty was experienced during the winter and spring terms in giving five or six laboratory courses with only three laboratories available. This lack of room made necessary the taking down of practically all of the laboratory apparatus at the end of each term, and setting up new laboratory apparatus for the following term's work.

This has indeed, been a trying year for the Physics Department, since only two of the regular teaching force remained with the department throughout the entire year, but notwithstanding this and the other unusual conditions that have prevailed, the work has been handled satisfactorily to all concerned.

Very respectfully submitted,
CHAS. W. CHAPMAN,
Head Physics Department.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF ENGLISH AND MODERN LANGUAGES.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the following report upon the Department of Engl sh and modern Languages for the year ending June 30, 1919:

TEACHING STAFF FOR THE YEAR.

The teaching staff of my department was as follows:

W. W. Johnston, Professor of English and Modern Languages.
E. S. King, Associate Professor of Public Speaking.
C. B. Mitchell, Assistant Professor of Public Speaking (Spring Term).
Mrs. A. C. Robson, Instructor in French.
Mrs. N. L. Roseboom, Instructor in English.
L. C. Hughes, Instructor in French.
J. B. Hasselman, Instructor in English.
R. B. Weaver, Instructor in English.
L. B. Mayne, Instructor in English.
O. M. Lebel, Instructor in French.
A. J. Van Speybroeck, Instructor in French.

Two members of the teaching force named above, Mr. Lebel and Mr. Van Speybroeck, were employed shortly before the opening of the fall

term. They came as instructors in French for members of the Student's Army Training Corps. After the disbanding of the Corps they were assigned to other work. Mr. Lebel took charge of one of our regular daily classes of first-year French and of four sections of conversational French, the latter subject being added to the curriculum with the beginning of the winter term. Mr. Van Speybroeck, who had had training and experience in teaching English as well as French, was assigned to instructional work in composition and public speaking for freshmen engineers.

At the beginning of the spring term the teaching force was augmented by the addition of Mr. C. B. Mitchell. In September, 1918, Mr. Mitchell, who had been a member of the department since 1912, resigned to accept a position with the Cincinnati office of the J. Walter Thompson Advertising Company. In March, 1919, he was reappointed to his assistant professorship in my department and was assigned to seventeen hours of class work for the spring term, fifteen in public speaking and two in composition.

I have not included, in the list given above, the name of Arthur S. Burket. Mr. Burket was a member of my department from the first of September 1916, to March, 1919; but from April, 1917, to the time at which he resigned his position at the College, he was on leave of absence, granted for the duration of the war. Mr. Burket was commissioned as Ist Lieutenant of Infantry in the Reserve Corps on April 17, 1917, and soon afterward was ordered to report at Fort Sheridan for active duty. He was assigned to duty with the 10th and 11th Provisional Regiments R. O. T. C. He was commissioned Captain of Infantry, R. C., August 15, 1917, was ordered to report to the Commanding General of Camp Custer, Michigan, and was assigned to the 338th Infantry. He was transferred to the 160th Depot Brigade, September 13, 1917, and assigned to Command of the 2nd Battalion. He was commissioned Major of Infantry, N. A., December 31, 1917. September 26, 1918, he was transferred to the 10th Infantry. While at Camp Custer, Major Burket served as President of the Camp General Court Martial, as Member of three Division General Court Martials, and as President and member of three Special Court Martials. He served also on the Summary Court of Brigade and Regiment, and was a member of various Promotion Boards, Efficiency Boards, Boards adjusting land claims, etc.

When Major Burket was transferred from the 160th Depot Brigade to the 10th Infantry, all signs pointed toward France; but within less than two months the armistice had been signed. Major Burket was discharged on February 6, 1919, and soon afterward went to Columbus, Ohio to make an address at the state meeting of ice cream manufacturers and to make arrangements for returning to East Lansing. While in Columbus, however, he was offered a very attractive opportunity to return to the practice of law, and resigned his position at the College. It was very shortly after his resignation that I had a chance to secure again the services of C. B. Mitchell for our work in public speaking. On March 14, 1919, Mr. Burket was recommissioned Major of Infantry, R. C.

Mr. Van Speybroeck, who was engaged in order that he might teach French to our unit of the S. A. T. C., will not remain with the department next year. Mr. Hasselman, whom you have appointed Director of Publications, retains his title of Instructor of English but will devote practically all of his time to publications. It is probable that he will teach for the Department of English only the two-hour course in Writing for the Press.

WORK OF THE MEMBERS OF THE DEPARTMENT DURING THE FALL TERM.

During the fall term much of the work done by members of the department was not in immediate connection with the department. The smallness of our enrollment of regular students, combined with the large amount of attention given to the S. A. T. C., necessitated important changes. As no English was given to our unit of the S. A. T. C., it was possible to spare the full time of two teachers. Accordingly, Professor King was for the term transferred to the department of Mathematics, for which he taught daily four classes of the S. A. T. C. Similarly, Mr. Hasselman gave his entire time to the Department of Physical Training. Three other teachers gave part time to the Department of History, in the teaching of War Aims. Mr. Weaver taught one section of 27 students in War Aims, in addition to teaching every week four two-hour courses and two three-hour courses in English—a total of six classes in English and one in War Aims. Mr. Mayne had two classes in War Aims, of 31 and 47 students respectively, besides teaching daily three sections of freshman composition for women, the smallest of these sections numbering 20 students. The head of the department transferred to Mrs. Roseboom his customary class in elective English for juniors and seniors and taught in their stead three classes in War Aims, of 23, 32, and 44 students respectively. As there was an enrollment of but 30 in English 2e, our regular course in freshman composition for agricultural students, he was also able to teach during his term all of the freshmen English given to our st dents of Agriculture. Mr. Lebel and Mr. Van Spreybroeck devoted their entire time to the courses on conversational French given to the S. A. T. C. There were but three members of the department whose instructional work was not wholly or largely determined by the war conditions prevailing at the College.

THE WINTER AND SPRING TERMS.

At the beginning of the winter term Professor King and Mr. Hasselman returned to service with the Department of English. The repeating of all term courses for students who had been in the army necessitated the organization of a considerable number of sections of new classes, and on the whole the work of the two terms was exceptionally heavy for all teachers of English. During the spring term the classes and theme work of some members of the department were made especially heavy by the necessity of relieving Professor King and Mrs. Roseboom of a sufficient amount of teaching to enable them to devote a considerable amount of time and hard work to the out-of-door play and the commencement pageant mentioned further on in this report. Likewise it seemed advisable to relieve Mr. Hasselman of his afternoon class work in order that he might fill temporarily the place left vacant by the resignation of the Director of Publications.

RESULTS OF CONTESTS.

Each year I have given in my report the results of contests in which the department is especially interested. This year the Eunomian-Holcad contest was won by Miss Ruth Hudson, H. E. '22, with a poem entitled *The Road*. Accordingly, Miss Hudson received the prize of $25 provided by the Eunomian Literary Society. There was a tie for second place be-

ween Miss Margaret Himmelein, H. E. '20, and Miss Helen Kellogg, H. E. '19. Miss Himmelein's contest manuscript was a story entitled *The Weakling*, Miss Kellogg's a story entitled *Spring Cleaning Invades the Store.* The sum of the second prize, $10.00, and third prize, $5.00 was divided between the two contestants, each receiving $7.50. Second and third prizes, as well as those awarded to contestants falling below third place, are provided annually by the Holcad. Other contestants who won prizes were Cecil Gebhart, H. E. '19; H. C. Powell, A. '22; Kenneth Mahrle, A. '22;W. A. Hockstad, A. '22; Ruth Musselman, H. E. '19; J. S. Cutler, A. '20.

The George E. Lawson Prize Essay contest was won by Mr. Stanley Powell, A. '20, whose essay was entitled *Living the Full Life on the Farm.* Second place was won by W. A. Hockstad, A. '22, for his essay *Our Friend the Fly.* Mr. Powell received the Lawson prize of $25, and Mr. Hockstad a prize of $15. Twelve manuscripts were submitted in this contest.

We took part in no intercollegiate debate this year. Iowa State College was ready to hold the usual debate, but Purdue University considered it better to wait one year. Various conditions led us to agree with Purdue.

COMMENCEMENT PAGEANT AND COMMENCEMENT DRAMA.

I believe that special mention should be made of the pageant planned and supervised by Mrs. Roseboom, of the department, and given on the evening of June 10th, as a feature of commencement week. It was a great success. The dances of all nations given in costume by all the girls of the College with the setting and background of our campus furnished an artistically beautiful and inspiring spectacle. It is hoped that this pageant may become an annual event.

The play given by the Dramatic Club on Monday evening of commencement week is likewise worthy of high praise. This production was directed by Professor E. S. King. The out-of-door performance of one of Shakespeare's plays under the direction of Professor King has become almost a regular feature of Commencement week. In previous years *As You Like It*, *A Midsummer Night's Dream*, and *Twelfth Night* have been given. This year the play was *The Merchant of Venice.*

In closing I wish to thank all the members of my department for their devoted and successful service to the College. Together with Professor King, Mrs. Roseboom and Mr. Hasselman, who in the spring assumed duties lying outside the strict boundaries of the department, should be mentioned Mr. Mayne, Mr. Weaver and Mr. Mitchell, who carried additional classes in order that the three first named might make a success of play, pageant and college publicity. I would also mention Mr. Lebel. Both in the classroom and outside of it he has made an enviable reputation during his first year. His worth to the College can by no means be measured by his services in the class room. To you, to Secretary Brown and to the members of the Board, I would likewise extend my sincere thanks for your unfailing consideration and encouragement.

Respectfully submitted,
W. W. JOHNSTON,
Professor of English and Modern Languages.

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF HISTORY.

President Frank S. Kedzie, East Lansing, Mich.

Dear Sir—I submit the following as my report for the Department of History for the year 1918-19.

The unusual conditions prevailing during the war required modifications of our regular departmental program. The Federal Government, in its program of training for soldiers included as one of the subjects to be given every soldier in training a course known as War Aims, which should set forth the historical causes of the war. This order made it necessary for this department to enlarge its activities.

Beginning with the men of the second vocational section, July 15th to September 15th, each man was required to attend one lecture per week, in which were heard discussed in consecutive order, the historical conditions existing from the foundation of the German Empire to the outbreak of the world war. In addition there was presented the reasons for each European nation being engaged in this war, as well as special emphasis upon the reasons for the entrance of the United States. Attention was also given to important results of the conflict, such as are found embodied in the Fourteen Points of President Wilson.

These lectures were repeated for the third vocational contingent, up to the signing of the armistice, except as they were interrupted by the scourge of influenza. In all, some twelve hundred men were handled in these two vocational groups. This work fell to the lot of the head of the department.

With the organization of the S. A. T. C. at the opening of the college year the governmental order included War Aims as a necessary part of the training of prospective soldier boys. This order brought five hundred more students into the department for three hours of work each per week. The work was conducted as follows: Each student was given one lecture per week in which current matters were dealt with. Effort was made to acquaint him with the developing conditions in Europe, many of which needed some historical survey in order to establish a clearer and more adequate understanding. For instance: such topics as the Polish problem, formation of states by the Czech-Slovaks and Jugo-Slavs, the Armenian troubles, the Russian revolutions together with an analysis of the governments of England, France, Germany and Austria. Also the cardinal principles of international law as understood by the allies were considered. These topics were of course integrally related to President Wilson's Fourteen Points and to the reason for the United States' part in the war.

In addition to this each student was a member of a second group in which two hours per week were devoted to the history of Europe from 1860 to the beginning of the war. In this course a text, Holt and Chilton's "European History," a book written for this purpose, was used. Some twenty sections were necessary, which were placed in charge of members of the faculty available for this purpose. The department takes this opportunity to acknowledge the services of Professors Bessey, Conger, Hedrick, Hasselman, Johnston; also Messrs. Mayne and Weaver.

Professor A. C. Conger constructed, with painstaking care, a large map, eight by eight, of Western Europe, which was exhibited in the corridor of the Agricultural Hall. On this was shown the positions of the Allied and the enemy forces. The changes in position were recorded for each day as the tide of the battle progressed. This contributed very materially for all, teacher and student, to an understanding of the facts about the war.

The War Aims course closed with the signing of the armistice for the vocational men and with the term end for the regular college student members.

With the coming of the winter term the department resumed its normal functions. The subjects scheduled for the winter and spring terms have been taught, but a depleted attendance has resulted in smaller classes.

For these terms the work has been handled by the regular staff. Mrs. Minnie Hendrick during the fall taught classes of young women and the men who were not in the S. A. T. C. work. In the later terms she has participated in the work as in former years. Thus I have briefly summarized the activities of a very busy as well as a very stirring year. We can only hope that our sevices have been of real value in aiding the twelve hundred men enrolled in the department in the understanding of the world war in all its multitudinous phases and that the importance of history as a study for any time has been demonstrated, not only to students in college, but the people in general.

Respectfully submitted,
E. H. RYDER,
Professor of History and Political Science.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF ECONOMICS.

President F. S. Kedzie, East Lansing, Michigan.

Dear Sir—The following is a report of the Department of Economics for the academic year 1918-19.

The total number of enrollments in the department for the year equalled 390, distributed as follows:

By terms—Fall, 44; winter, 115; spring, 181; summer, 50.

By classes—Senior and junior, 103; sophomore, 199; freshmen, 88.

By subjects—Economics, 229; Sociology, 61.

Total number of hours taught during the year, exclusive of S. A. T. C. hours by members of the department are 912, divided as follows:

By terms—Fall, 72; winter, 300; spring, 360; summer, 180.

By subjects—Economics, 732; Sociology, 180.

The use of the college for S. A. T. C. purposes during the fall term cut down the work of the department to two classes, one for non-military upper classmen and the other for the freshmen who were under draft age. Both the members of this department did S. A. T. C. teaching throughout the fall term, Mr. Dunford having five hours of S. A. T. C. economic teaching and 10 hours of supervision per week, Mr. Hedrick having 10 hours per week of War Aims.

In the winter term the department offered its customary number of courses as is true also of the spring and summer terms. That the average attendance is so much reduced as compared with previous years is due to the fact of student absences from college on account of military duty.

In the college curriculum revisions which seemed suitable this year as a result of war alterations, economics was removed from the sophomore year of the Engineering course and transferred to the senior year. In the Agricultural course some consolidations of two and three-hour subjects in economics into five-hour subjects were made. This it was thought would give more unity to the offerings of the department.

Both members of this department have had the customary general or non-classroom services to perform. Professor Dunford assisted during many hours with the courses in Telegraphy for soldiers which was given here. The head of the department had his usual employment on the Social Committee, Course of Study and Book Store Committees, and upon the Executive Councils of the M. A. C. Union and M. A. C. Association. He also gave a dozen or more public addresses in various localities upon various practical economic questions.

Respectfully submitted,
W. O. HEDRICK,
Professor of Economics.

East Lansing, June 30, 1919.

REPORT OF THE DEPARTMENT OF PHYSICAL TRAINING.

To the President, Michigan Agricultural College.

Sir—I respectfully submit the following report covering the work of the Department of Physical Training for the college year 1918-19.

The fall term was given over entirely to work with the students of the Student Army Training Corps; the department staff cooperating with the military authorities in carrying on a comprehensive program of physical drill, recreation and athletics. This work became a valuable part of the work and life of these men stationed here in military service and contributed very largely to the morale, spirit and health of the group.

January saw the activities of the department return to normal with required physical work, twice a week of all freshmen men, and of all sophomore and junior men, not taking military, and three periods a week of all girls except seniors. The usual athletic teams were developed and a great deal of time and effort was given to mass athletics and general recreation for the entire student body.

The work with girls developed very largely during the year. All of their work was brought into the new gynmasium, another competent instructor was added and the work broadened and extended by adding swimming and recreative games.

The faculty has given the department added standing and opportunity by voting to require physical training of all students, beginning with the opening of college in 1919, except during the spring term of the senior year. The faculty also took steps to establish a Health Service for the college. This health service will demand a physical examination of all students on entering and supervision and education in all health matters.

The new gymnasium, which came into full use for the first time during the past year, has proved splendidly arranged and adapted for all the work of the department and has already proved it will contribute very materially to the health and education of all who come to the institution as students.

The department badly needs improved and larger athletic and recreative fields. The present field is not only small, but is so frequently flooded from the waters of the Red Cedar that a great deal of time and materials are lost each year and, too, the danger of damage makes it unwise to attempt extensive improvements. The present stands are wooden and in bad condition and immediate steps must be taken to build substantial and adequate accommodations.

The department staff was considerably broken up, on account of military service, but through adjustments and the willingness to carry extra work, the institution did not suffer materially. The Director of the department was on leave of absence until Feb. 8, 1919, serving as Director of Physical Training and Recreation for the Southern Department of the army. L. L. Frimodig served as Lieutenant in the Artillery and came to the department as instructor Jan. 1, 1919. George E. Gauthier spent six weeks in the college instructors training camp, early in the year, but returned in October and in addition to his regular duties as instructor, acted as head of the department, until Feb. 8th. Miss Edith Casho and Miss Helen Grimes, instructors in the work for women, were in attendance the full year and handled their work admirably.

The above staff is well trained and faithful and will all return for the year 1919-20.

Respectfully submitted,
C. L. BREWER,
Director, Department of Physical Training.

East Lansing, Mich., June 30, 1919.

REPORT OF THE LIBRARIAN.

President F. S. Kedzie.

Dear Sir—I have the honor to present the following report on the library for the year ending June 30, 1919.

During the year there have been added to the library by purchase 528 volumes; by binding, 539 volumes and by gift 184 volumes. Total additions, 1,251 volumes. Total number in library, 39,843.

For bound volumes we are indebted as follows:

Beal, Dr. W. J., 1
California, 1
Carnegie Endowment for International Peace, 1
Canada, 27
Chapman, Prof. C. W., 1
Connecticut, 2
Goodrich Rubber Co., 1
Hinebaugh, T. D., 13
Halligan, Prof. C. P., 1
Iowa, 5
Illinois, 3
Florida, 1
Kansas, 3
Maine, 4
Massachusetts, 9
Michigan, 49
Minnesota, 1
Montana, 2
Missouri, 2
New York, 12
Nebraska, 6
New Jersey, 6
North Carolina, 1
New Hampshire, 1
Ohio, 1
Osborn, Hon. C. S., 1
Penn., 34
Smithsonian Institution, 3
Thum, Wm., 1
Tennessee, 1
United States, Reports, 11
U. S. Veterinary Medical Assn., 3
Vermont, 4
Wheeler, Wm. R., 1

Of unbound books and pampnlets 335 have been added, of which 3 were purchased. Total number of pamphlets, 9,734. When donors were known acknowledgement was made.

The following is a list of publications received by the library as gifts from publishers, or in exchange for our reports and bulletins.

Agrl. Gazette of Canada.
Agrl. Gazette of N. S. Wales.
Agrl. Review.
Allegan Gazette.
America.
American Economist.
American Farming.
American Fruit Grower.
American Food Journal.
American Hebrew.
American Iron and Steel Institute, Bulletin.
American Issue.
American Miller.
American Poultry Advocate.
American Sheepbreeder.
American Swineherd.
Annals of the Missouri Botanical Gardens.
Armada Times Graphic.
Ayreshire Quarterly.
Australasian.
Australian Museum, Records.
Bean Bag.
Boy Power.
Brooklyn Botanic Garden Record.
Belding Banner.
Berkshire World and Cornhill Stockman.
Better Business.
Better Fruit.
Blue Valley Bulletin.
Boletin de Agricultura, Sao Paula.
Bulletin of the Grand Rapids Public Library.
Bulletin N. Y. Botanic Gardens.
Bulletin Pan American Union.
Bulletin Boston Museum of Fine Arts.
California Acad. of Science, Proc.
Canadian Forestry Journal.
Canadian Horticulturist.
Canal Record.
California Citrograph.
Chester White Journal.
Community Life.
Chicago Packer.
Christian Science Journal.
Christian Science Monitor.
Christian Science Sentinel.
Commerce Reports.
Congressional Record.
Dairy Record.
Dakota Farmer.
Deutsch Amer. Farmer.
Doherty News.
Edicon Monthly.
Electric Railway Journal.
Electric Traction.
Elgin Dairy Report.
Eaton Rapids Journal.
Etude.
Farm and Fireside.
Farm and Home.
Farm and Ranch Review.
Farm Journal.
Field.
Field and Farm.
Flour and Feed.
Fruit Belt.
Fruitman and Gardener.
Guernsey Breeders' Journal.
Guaranty News.
Guaranty Trust Co., Letters.
Hoard's Dairyman.
Holcad.
Holstein-Friesian World.
Hospidor.
Illuminating Engineer.
India, Agricultural Publications.
Indian's Friend.
Illustrated Review.
Improvement Era.
Indiana Farmers' Guide.
Investment Bankers' Assn. of America, Bulletins.
Indicator.
Ingham Co. News.
International Institute of Agriculture, Rome. Publications.
Il Giornale d'Italia Agricolol.
Jersey Bulletin.
James' Barn Magazine.
Johns Hopkins University, Circulars
Journal of Agrl. Research.
Jl. of the Bd. of Agrl. and Fisheries, London.
Jl. of the College of Agrl., Tokio.
Jl. of the College of Agrl., Sapporo.
Jl. of the Dept. of Agrl., S. Australia.
Lilly Scientific Bulletin.
Lincoln Frie Presse.
Lister Institute of Preventive Medicine, Trans.
Live Stock Reports (Clay Robinson)
Manton Weekly Tribune.

Midland Sun.
Market Growers' Journal.
Message of the East.
M. A. C. Record.
Michigan Farmer.
Midland Naturalist.
Moderator Topics.
Modern Gladiolus grower.
Monthly Bulletin, Comm'r of Hort., California.
Monthly Crop Report.
Monthly Review, U. S. Labor Bureau.
Michigan Business Farmer.
Michigan Library Bulletin.
Michigan Patron.
N. Amer. Teacher.
Nut Grower.
National Farmer.
National Grange Monthly.
National Stockman and Farmer.
National Weather Bureau and Crop Bulletin.
N. Y. Meteorology, Draper's Hourly Readings.
N. Y. Produce Review.
Official Bulletin.
Official Gazette.
Ohio Farmer.
Orange Judd Farmer.
Our Dumb Animals.
Pan American Bulletin.
Pacific Dairy Review.
Park and Cemetery.
Poland China Journal.
Power Farming.
Practical Farmer.
Proc. Amer. Philos. Soc., Phila.
Progressive Herald.
Public Health Reports, U. S. Marine Hospital.
Publicity Magazine.
Reclamation Record.
Philippine Agrl. Review.
Philippine Agriculturist and Forester.
Philippine Bureau of Science, Reports.
Porto Rico Jl. of the Dept. of Agrl.
Progressive Farmer.
Rice Institute Pamphlets.
Rhodesia Agrl. Journal.
Rockefeller Institute for Medical Research, Studies
Russia.
Scientific Monthly.
Seed World.
Scripps Institute for Biol. Research, Bulletins.
Short Horn in America.
State Plant Board of Florida, Quarterly Bulletin.
Smithsonian Institution,
  Miscel. Collections.
  Contrib. to U. S. Nat. Herbarium.
  Bulletin of U. S. Nat. Museum
Social Service Review.
Southern Fruit Grower.
Special Crops.
Sugar.
Sunkist Courier.
University of California, Publications,
  Agrl. Science.
  Zoology.
Useful Poultry Culture.
Wallace Farmer.
West Coast Leader, Peru.
Washington Farmer.
Weather Review.
Weekly News Letter.
West Indian Bulletin.
Western Honey Bee.
White Breeders' Companion.
Williamston Enterprise.
Wilson Bulletin.

The publications of the U. S. Dept. of Agriculture and the bulletins of the various Agrl. experiment stations, together with the card indexes, are received and filed in the library.

The catalogues of the leading educational institutions of the country are received and filed. These are received in exchange for our own catalogue.

The number of books loaned for home use was 5,118, an average of about 427 per month. No record is kept of books used in library.

For our student assistant, Mr. Fowle, we have only words of commen-

We are indebted to the U. S. Department of Agriculture and the University of Michigan for books loaned to us during the year, and desire to express our appreciation of the courtesies extended to us by the librarians in charge of these libraries.

The library of the experiment station grows but slowly. The additions during the year number 187, of which 15 were by purchase, 163 by binding, and 9 by gift. The two libraries now number 44,556 volumes.

On the evening of May 12th, Governor Sleeper signed the Bill which appropriated $300,000 for a new library, and we are now looking forward to the erection of the building for which we have so long waited.

We are sure that every one, faculty, student and alumni, join with us in thanking the State legislature for recognizing our need and meeting it, and the Governor for signing the Bill, thereby making it effective.

Respectfully submitted,
LINDA E. LANDON,
Librarian.

East Lansing, June 30, 1919.

REPORT OF THE REGISTRAR.

President F. S. Kedzie, Michigan Agricultural College, July 15, 2919.

Dear Sir—I have the honor to present the following report of the Registrar's Office for the year ending June 30, 1919.

At the opening of the college year on October 1st, 1918, a unit of the Students' Army Training Corps was established and continued in operation throughout the greater part of the term. The courses offered to the members of this unit were mainly those outlined by the Committee on Education and Special Training of the War Department to prepare men for the following branches of service: Infantry and Artillery; Air Service; Chemistry; Engineering; Tank and Transport; Signal Corps; Quartermaster; and Ordnance.

The courses were arranged according to the plan of the Committee, in three groups. The first for those eighteen years of age, the second for those of nineteen years of age and the third for those of twenty years or more. The following table shows the number in each group.

Eighteen year group			149
Nineteen year group	Infantry and Artillery	59	
	Air Service	30	
	Engineering	41	
	Tank and Transportation	36	
	Signal Corps	13	
	Quartermaster	18	
	Chemistry	4	
Total			201
Twenty year group	Infantry and Artillery	93	
	Air Service	32	
	Engineering	37	
	Tank and Transportation	24	
	Signal Corps	13	
	Quartermaster	16	
	Chemistry	5	
	Ordnance	3	
Total			223
Unassigned		13	
Veterinary Medicine		36	
Total number classified			622
Students registered and inducted into the Corps but who were sent to Officer's Training Camps before Classification			56
Died of Influenza			9
Total number registered			687

Of this number 53 were enlisted as members of the Naval unit, but owing to the small number they were assigned to one of the companies in the Army unit and are included in the foregoing groups.

In the regular college courses the enrollment for the year is as follows:

Agriculture and Forestry	314	
Engineering	244	
Home Economics	329	
Veterinary Medicine	41	
Total		928
Summer Session, 1918		180
Two years courses in Agriculture	24	
Eight Weeks Courses in Agriculture	169	
Four Weeks Course in Farm Tractors	166	
Total		359
Soldiers and Sailors preparatory		11
Total		1,478
Names repeated		109
Net Total		1,369

ENROLLMENT BY TERMS.

Course.	Fall.	Winter.	Spring
Agriculture and Forestry	61	259	290
Engineering	54	231	224
Home Economics	306	303	291
Veterinary Medicine	10	42	40
Graduate	7	10	7
Soldiers and Sailors Preparatory			11
Totals	438	845	863

ENROLLMENT BY CLASSES.

	Agriculture and Forestry	Engineering.	Home Economics.	Veterinary Medicine.	Total.
Graduates	6		5		11
Seniors	62	23	64	16	165
Juniors	64	32	76	13	185
Sophomores	59	57	62	7	185
Freshmen	108	132	110	5	355
Special Students	15		12		27

GEOGRAPHICAL DISTRIBUTION OF STUDENTS.
MICHIGAN.

COUNTIES:					
Alger	1	Hillsdale	13	Missaukee	1
Allegan	11	Houghton	10	Monroe	7
Alpena	4	Huron	14	Montcalm	5
Antrim	5	Ingham	187	Montmorency	1
Arenac	1	Ionia	17	Muskegon	9
Baraga	1	Iosco	5	Newaygo	4
Barry	3	Iron	1	Oakland	16
Bay	7	Isabella	2	Oceana	13
Benzie	3	Jackson	25	Ogemaw	1
Berrien	17	Kalamazoo	13	Ontonagon	2
Branch	7	Kalkaska	2	Osceola	5
Calhoun	16	Kent	32	Ottawa	11
Cass	8	Lapeer	15	Presque Isle	1
Charlevoix	5	Leelanau	1	Roscommon	2
Cheboygan	4	Lenawee	17	Saginaw	21
Clare	1	Livingston	7	Sanilac	15
Clinton	11	Luce	1	Schoolcraft	1
Delta	5	Mackinac	1	Shiawassee	19
Dickinson	5	Macomb	7	St. Clair	18
Eaton	27	Manistee	4	St. Joseph	9
Emmet	4	Marquette	3	Tuscola	2
Genesee	20	Mason	10	Van Buren	16
Gladwin	3	Mecosta	3	Washtenaw	7
Gogebic	1	Menominee	1	Wayne	47
Grand Traverse	14	Midland	4	Wexford	1
Gratiot	11				

[OTHER STATES AND COUNTRIES.

California	2	Kansas	1	New York	24
China	2	Kentucky	2	Ohio	26
Connecticut	2	Maine	1	Oklahoma	1
Delaware	2	Maryland	1	Pennsylvania	4
Florida	2	Mexico	1	Phillipine Is.	1
Greece	1	Massachusetts	2	Texas	1
Illinois	19	Minnesota	3	Vermont	5
Indiana	3	New Hampshire	1	West Virginia	1
Japan	1	New Jersey	4	Wisconsin	2

STUDENTS ENTERING DURING THE YEAR 1918-19.

Number Enrolled.

Agricultural and Forestry Course	107	
Engineering Course	124	
Home Economics Course	115	
Veterinary Medicine Course	14	
Total		360

Preparation.

Graduates of Accredited High Schools	317	
High School Credits and Examinations	8	
Credits from other Colleges	35	
Total		360

DEGREES GRANTED JUNE 11, 1919

BACHELOR OF SCIENCE.

a, Agriculture; e, Engineering; h. Home Economics; f, Forestry.

Allen, Esther Caroline, h.
Allen, Winston Fields, a.
Bandeen, Nellie Allyn, h.
Bartley, Hugh Jerome, a.
Baxter, Raymond Leroy, e.
Benjamin, Ruth Irene, h.
Blair, Sherli Constance, h.
Brunson, Alice Plathynia, h.
Bugai, Joseph Walter, a.
Carmody, Martin Francis, a.
Carrow, Harold Glenn, e.
Chapman, William Alvan, a.
Clements, Leila Electa, h.
Cobb, Ada Frances, h.
Cole, Olive Gertrude, h.
Cook, Margorie Elizabeth, h.
Copas, Margaret Erlamond, h.
Cottrell, Lavenia Esther, h.
Deadman, Hazel Belle, a.
Diehl, Helmut Charles, f.
Diehm, Oscar Adam, a.
Dilts, Madge Emma, h.
Dunlap, Nenna Beatrice, h.
Dunphy, Audrey Ann, h.
Edmonds, Helen Abigail, h.
Edmondson, Margery Thornton, h.
Fitzpatrick, Frank Wellington, a.
Folks, James Nathan, a.
Gilbert, Vera Murree, h.
Gordon, Gladys, h.
Hall, John Winkley, h.
Hallet, Esther Elizabeth, h.
Hath, Minty E., a.
Hodgeman, Ruth Kathryn, h.
Holliday, Margaret Emma, h.
Hopphan, Ethel Linna, h.
Hoyt, Warren John, a.
Hubbard, Louise Harriet, h.
Illenden, Jessie Lillian, h.
Johnston, Margaret Julia, h.
Kahres, Dorothy Elisabeth, h.
Keiser, Jessie Aletha, h.
Kelley, Walter Thomas, a.
Kellogg, Helen Elizabeth, h.
Kelty, Russell Hiram, a.
Kent, Daniel Webster, a.
Kitti, Alma, h.
Kober, Claudice Mary, h.
Kuder, John McCloud, a.
Kurtz, William Jennings, a.
Landstrom, Louisa Dorothea, h.
Lee, Clarissa Pike, h.
Lindsay, Emerson Joel, a.
Lott, Esther Catherine, h.
McBride, Lois, h.
McIntyre, Agnes Lillian, h.
McNinch, Marletta Jane, h.
Mahrle, Helen Bartlett, h.
Mead, Harold Charles, a.
Mead, Helen, h.
Mead, Mildred, h.
Millard, Forrest Gass, e.
Moore, Irma Clarice, h.
Muhlitner, Hazel Mary h.
Musselman, Ruth Fern, h.
Ode, Francis, a.
Overhiser, Frances Leona, h.
Porter, Elizabeth Sanford, h.
Pratt, Martha Simpson, h.
Preston, Erma Elfleeda, h.
Rainey, Boyd A., a.
Reed, Newton Luther, e.
Rogers, Gertrude May, h.
Roland, Kenneth Henry, a.
Rusche, Dorothy Katherine, h.
Sardjoff, Cristho a.
Schneider, Bert Leonard, a.
Siefert, William Alfred, e.
Smith, Marian Irene, h.
Snyder, LeMoyne, a.
Southard, Ordelia Harriet, h.
Spafard, Ethel Maria, h.
Spelts, Arthur Francis, a.
Spencer, Francis Gertrude, h.
Spinning, George Wilson, a.
Stark, Harold Clifford, a.
Sutherland, Hazel Matilda, h.
Sweeney, Ralph Crissman, e.
Templeton, Marion Louise, h.
Thomas, Marian Craven, h.
Tucker, Ada Dyer, h.
Vaughn, Frank Luther, a.
Walker, Ruth Louise, h.
Weld, Elizabeth Phelps, h.
Younker, Elwyn Dorr, a.
Snyder, Margaret Louise, h.

DOCTOR OF VETERINARY MEDICINE.

Baxter, Earle Gilbert
Colby, Stanley Gould
Dunn, Alexander Renny
Flower, Kellogg Loyal
Gordon, Max Matthew
Hanson, Karl Burchard
Krueger, Keith Fortune
LaBar, Chauncey Floyd
Robbins, Bernard Dewitt
Smith, Edwin Reed
Tenney, Gerald Dean
Tenney, Norman Harrison
Trubey, George William
Welsh, Mark Frederick

MASTER OF SCIENCE.

Foster Rudolph
Ruth Dorothy Normington
Stanley George Bondeen

CHEMICAL ENGINEER.

Henry Eveleth Publow

MECHANICAL ENGINEER

Harold Madison Jacklin.

MASTER OF FORESTRY.

Earl C. Sanford.

MASTER OF HORTICULTURE.

Harold Sterling Bird
Edmund Harrison Gibson

Irvin Thomas Pickford.

DEGREE GRANTED NOVEMBER 20, 1919.

BACHELOR OF SCIENCE.

Frank E. Semon, was of Class of '89.

DEGREES GRANTED DECEMBER 20, 1918.

BACHELOR OF SCIENCE.

Amiotte, Zeneda Marie, h.
Bigelow, Zella Ethel, h.
Fogle, Floyd Earl, a.
Higgins, Ethel Mabell, h.
Kessler, Nicholas Aloysius, f.
Laidlaw, Orville William, a.
Sims, John Wilson, a.
Snow, Alta Ada, h
Weidemann, Andrew George, a.
Wood, Wilbur Warren, a.

DOCTOR OF VETERINARY MEDICINE.

Stanley George Bandeen.

SUMMARY OF DEGREES GRANTED DURING THE YEAR OF 1918-19.

Bachelor of Science:		
Agricultural Course	36	
Engineering Course	8	
Home Economics Course	62	
Forestry Course	2	
		108
Doctor of Veterinary Medicine		15
Master of Science		3
Professional Degrees		6
		130
Names repeated		1
Total		129

The efficiency of this office has been greatly increased by the addition of two safe filing cabinets to our equipment. These cabinets are fire proof and are sufficiently large to enable us to store all the student records of the College besides other valuable reports.

At this time I wish to express my appreciation of the assistance rendered by my co-workers, Miss Anna Ferle, Assistant Registrar, and Miss Agnes Kerr, who has been employed as stenographer during the year.

Respectfully submitted,
ELIDA YAKELEY,
Registrar.

East Lansing, June 30, 1919.

REPORT OF THE MILITARY DEPARTMENT.

President F. S. Kedzie:

The undersigned was relieved from duty at this institution on Sept. 19, 1918, to take command of the S. A. T. C. at Wesleyan University, Connecticut, and returned to duty here Jan 2, 1919.

The usual troubles incidental to a period of re-construction were experienced, the students being sick of military training and the apparent hopeless purpose of the S. A. T. C. For three month the students "bucked" but were finally won over to the safe and sane view of military training and then settled down to make up for lost time. The students who had been the strongest in opposition became the strongest supporters of the department.

The corps carried out *everything* desired by the War Department—in brief with but two terms available, we covered the ground laid kown for three terms. The gallery firing showed a noticeable improvement over that of the preceding year. Last year the students fired an average of 84%, this year, 87%, with the War Department requiring but 60% a *standard, the attitude of the students and their ability to DO work when* given them in the right way is well illustrated.

The annual inspection, given by Lt. Col. Hester, General Staff, was in the early part of May. All day Friday and all the morning of Saturday were devoted to demonstrations, each and every phase of our instruction. This demonstrating was carefully planned and most successful. Col. Hester stated that we had done everything that the War Department wanted, in the way the department wanted and was more than pleased. "You do not appear to have been affected at all by the S. A. T. C. interruptions as were the other colleges". At the review he thought we had practiced a long time and was surprised that the students had had only two prior drills in the formation. He asked more questions than any inspector I have yet had and more than 90% of the questions were answered correctly and promptly.

As a result of the inspection, Michigan Agricultural College was placed in the "Distinguished Class" by War Department orders. This is the first *time in the long history of M. A. C. that the college has gained this high* honor. Only 12 colleges in the entire United States are so designated and four of those are essentially military schools such as Virginia Military Institute and The Citadel.

With three full terms ahead foı next year there is no reason to doubt our ability to again gain honors. Cadet Major Daniel W. Kent, class of 1919, was, with the approval of the president, nominated as "Honor Graduate" and certified as eligible to appointment as second lieutenant in the regular army. I have not yet heard whether he has been appointed but he doubtless will be as soon as a vacancy and new appointments occur.

Sgt. Chas. H. Robinson deserves great praise for his unswerving loyalty and tactful manner in handling the students during the trying times of reconstruction.

Respectfully submitted,
P. G. WRIGHTSON,
Major U. S. Army.

East Lansing, June 30, 1919.

SUMMER QUARTER REPORT.

President F. S. Kedzie, College.

My dear Sir—On January 27, 1919 the faculty voted as follows: "It is recommended that the summer session be extended to two terms of six weeks each, the courses of each term to begin and terminate within each such term."

Also, "That the committee recommend to the faculty that the Board of Agriculture be asked to authorize the giving of a one year's special college preparatory course to soldiers and sailors who desire to pursue a four years' course, but have not completed a High School course."

Upon these two pieces of legislation the plans of the summer quarter have been developed and administered. The purpose voiced in the above cited legislations of the faculty was special service to two classes of individuals viz., the regular students of the institution and another group who had never enrolled.

The needs of the first group were occasioned by the fact that the men had been drawn into the military service, resulting in the loss of one or more terms of college work. In a large number of cases the loss was confined to the fall term of the year 1918, since the signing of the armistice instituted the process of returning men to civil life sufficiently early to enable many students to resume college courses with the second term, beginning in January. Others arrived at different times in the successive weeks. Obviously, these men could not complete their year's work at the end of the regular year. It is equally clear that many would be delayed the whole or the greater part of another college year unless courses could be made available earlier. The College adopted the policy of reinstating every student in his work in the most advantageous way. Engineers resumed with fall work because of prerequisites; agriculturals pursued winter subjects at once. In any case an additional quarter was necessary to complete the year of work before the next college year. For senior engineers the spring term work would be needed while agricultural students would need the fall subjects.

For underclassmen there were two reasons for relief. In the case of many engineers, there was necessity for removing prerequisite work in order to classify in the next college year. In other cases it was a matter of catching up in one's course.

To meet these needs the College took the above steps in deciding to offer two summer terms for the accommodation of these men. Such courses as would enable seniors one term in arrears to complete their courses; prerequisite courses for underclassmen; and a liberal number of other courses to assist any students to advance satisfactorily in their respective courses. The provisions made for returned soldiers and sailors were maintained through the terms of the summer quarter. As a result a number of men will be in readiness for entrance to college at the opening of the fall term. The statistics below show to what extent the student body and soldiers and sailors availed themselves of this service.

	First Term.	Second Term.
Number of Agricultural Students in Attendance	118	46
Number of Engineering Students in Attendance	116	27
Number of Home Economics Students in Attendance	48	2
Number of Veterinary Students in Attendance	5	1
Number of Post-Graduate Students in Attendance	7	5
Number of Rural School Teachers in Attendance	12	0
Number of Preparatory Students in Attendance	14	14
Number of Special Students in Attendance	62	11
Total	381	106

	Agricultural.		Engineering.		Home Economics.		Veterinary.		Preparatory.		
Term	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	
Graduate	7	5	....	....			....	....	....	....	....
1919 Seniors	21	4	13	9	1	....	....	....	....	....	....
1920 Seniors	47	14	28	1	13	....	....	....	....	....	....
Juniors	20	11	32	7	15	1	2	....	....	....	....
Sophomores	26	12	38	9	15	....	1	....	....	....	....
Freshmen	5	6	12	3	4	1	2	1	....	....	....
Special	20	6	....	....	46	2	....	....	....	....	....
Preparatory	....	....	....	....	....	....	....	....	14	14	....
Total	146	58	123	29	94	4	5	1	14	14	....
Total First Term	....	....	....	....	....	....	....	....	....	....	381
Total Second Term	....	....	....	....	....	....	....	....	....	....	106
Total for Quarter	....	....	....	....	....	....	....	....	....	....	487

Number of Courses—Agricultural, 18; Engineering, 22; Home Economics, 9; Veterinary, 1; General Science. 56.

Number of students completing courses during summer quarter—Agricultural, 25; Engineering, 14; Home Economics, 1; Veterinary, O.

Number of Instructors—1st term, 66. 2nd term, 20.

Total cost for instruction—1st term, $13,059.50; 2nd term, $4,000.

Number of former students enrolled—1st term, 143. 2nd term, 86.

Number of new registrants—2nd term, 25.

Number of students in residence both sessions, 81.

Special Lecturers for Conference and Summer Quarter.

Dr. L. H. Bailey, Ithaca, New York, one lecture.

Dr. Lloyd C. Douglas, Ann Arbor, Michigan, two lectures.

Dr. A. E. Ross, Madison, Wis., four lectures.

Prof. H. H. Severn, Kalamazoo, Michigan, ten lectures.

Summer School Attendance in 1915		223
Summer School Attendance in 1916		175
Summer School Attendance in 1917		239
Summer School Attendance in 1918		182
Summer School Attendance in 1919	(1) 381	
	(2) 106	
		487

The above statistical data is given in anticipation that it may answer a large number of inquiries concerning the summer quarter; also that it may serve as a basis for determining the future policy of the college relative to summer session activities. While the present quarter has been offered as an emergency session, it is inevitable that the question shall arise as to whether the institution ought to be kept open for a full quarter during the succeeding summers.

It may not be amiss at this point for me to direct attention to certain considerations pertaining to the session just closed.

First. There is no question as to the wisdom of this year's policy of the faculty. Many students have been very materially assisted by being able to complete their course this summer; in fact, we would have been negligent of our obligations if we had done otherwise than to make available a quarter's work in this particular year.

Second. There can be no doubt that many students were here not because of war emergency, but because they desired to hasten the date of graduation. The young women came largely in this class. It is impossible to give the exact figures for the men. This means that there is some inclination on the part of the student body to make use of a full summer quarter. The problem as to how great an obligation rests upon the College to furnish the opportunity is one that may well be studied before it is disposed of. At least it should not be dismissed without the hearing which educational interests and policies demand today. The fact that such universities as Cornell and Missouri have arranged their curricula for summer period is evidence of the attitude of these colleges. I suggest that a committee of three be appointed by the President to consider this question and report its findings at an early meeting of the faculty.

Third. The activities of this season have made the most extensive use of the institution's educational facilities that has been made during the summer in recent years. It raises the question as to what extent the great equipment of such a plant should be actively employed in an educational capacity throughout the year.

Fourth. The benefit of the summer session has not been wholly in behalf of the student. This year in particular it has given to the teaching force a supplementary employment at a time when our salary problem is peculiarly delicate. It is an admitted fact that teachers are suffering excessively from the high cost of living. The additional income of this season has been a welcome boon at this time.

Fifth. Reference to the statistics shows the presence in our summer session of a considerable number of students who are not regular attendants of the College. Experience has proven that it is a difficult matter to attract these outsiders. However, they are in most instances, a very valuable addition to our student body. I believe it would be an effort worth while to endeavor to secure a larger enrollment of this type of student. Strange as the statement may seem, still I believe it to be true that there are many who do not realize the opportunities which this institution affords in an educational line. It may be expected that through the development of education along the line of agriculture and home economics under the Smith-Hughes legislation, the College is going to find many mature men and women coming to its campus for the instruction

necessary for public school work. This summer's enrollment has shown this. The summer period is advantageous for such students and we may well prepare to render the service for all such and for others who may be attracted here for various purposes.

A very excellent feature was introduced this year in the form of a series of lectures, extending through one week, by the faculty of the Agricultural Division for the benefit of teachers of agriculture in the high schools of the state. This project was in charge of Professor French and Director Gallup. These men, the most of whom had been out for some time, pronounced it a very valuable service.

Several conferences were held during the first six weeks. Reports for those in Home Economics and Boys' and Girls' Clubs appear elsewhere. The Rural Conference deserves a word in this report. This conference brought to the campus for one week more than one hundred men and women, chiefly rural ministers. Of these forty men enrolled in the short course work for one week and fifteen remained for a second week of this work. This effort of the College in holding a conference and short course work is directed toward men and women occupying conspicious and responsible places in society and is well worth while in its results for community betterment. The prospects for its growth and greater efficiency were never more promising than at the close of this season's conference.

In closing I would call your attention to the work of our students during the quarter. It has been a term of exceptional hard, earnest work on their part, and I think more has been accomplished in the courses than is done in the regular terms.

The splendid cooperation of our teachers has made the quarter one of profit and success for the College. As director, I am greatly indebted to Professors A. C. Conger and C. S. Dunford for assistance in classifying students.

Respectfully submitted,

E. H. RYDER,

Director Summer Sessions.

REPORT OF THE ALUMNI RECORDER FOR THE YEAR 1918-1919

President F. S. Kedzie, Michigan Agricultural College.

Dear Sir—The following is the annual report of the Alumni Recorder for the period beginning July 1, 1918 and ending June 30, 1919.

The work of keeping in touch with the alumni of the College has gone forward during this period under conditions such as have rarely obtained before. The war situation up until the signing of the armistice, when such great numbers of men were drawn into the conflict either in active service in the army and navy or in civilian branches, followed by the rapid demobilization at the close of the war and the returning of our men to civilian occupations has placed an unusual task upon the alumni office.

Our records show that over 1,400 M. A. C. men went into active service for the nation with the army and navy exclusive of the S. A. T. C. We are now working up the service records of each of these men and gathering as much data and information as possible looking toward the publication of a history of the College during the war. Already we have completed records with photographs for nearly 1,000 of these men and the rest are being gathered as rapidly as possible. Some forty of our graduates and former students gave their lives in the great conflict and at commence-

ment time a grove was planted in their memory and a tablet containing their names has been placed upon a field stone at the edge of the grove.

Not only has the College made a wonderful showing in the number of her sons that responded to the call of the nation but these men individually have carried themselves throughout the fighting on the allied line in such a manner as to bring added honors to the brilliant record of the institution. Between fifteen and twenty graduates and former students have won decorations from the United States government and from French and British governments for valor and distinguished service in action. One of our men, Harold Furlong, with the class of 1918, was awarded the Congressional Medal of Honor which is the highest reward that the United States can give her soldiers. Less than fifty such decorations were made during the war and to have an M. A. C. student receive one of these is a distinct honor.

The War History work that I have mentioned above now being undertaken in sequence of the collection of the war records of the individual soldiers and sailors of M. A. C., contemplates a historical recording of the activities of the institution during the war and the war work that was carried on on the campus by the various departments.

As a gift from the College and from the M. A. C. Association 980 men were receiving the M. A. C. Record, the College weekly publication, at the time of the armistice. That they appreciated this gift and that it has won much favor for the College is shown by the many letters of thanks which our men have sent in regarding it.

The work of reorganizing the local alumni associations was taken up immediately after the closing of the war and up to the first of June ten of the branch M. A. C. Associations had reorganized and were back on a pre-war basis. The mother association also demonstrated that it was returning to a normal state through a reunion at commencement time, June 11th, attended by over 500 enthusiastic graduates and former students. Alumni support was solicited and bountifully given to the legislative measures passed by the present legislature providing appropriations for two new buildings for the campus. The alumni gave their active support and were largely responsible for bringing both measures to a successful passage.

The outstanding feature of the year's work has been the launching of a campaign for a Union Memorial Building. A Union Building at the College has been talked of for several years and with the close of the war there was immediately presented the question of an appropriate memorial to those men of ours who gave their lives in the great struggle and to the men and women of the College who participated in it actively. It appeared to the executive committee of the alumni organization that the memorial could well take the shape of a Union Building and as such be a permanent and very useful commemoration to our war heroes. It is the idea that the building will serve as a community and social center for the campus and be a college home for students, alumni, faculty and friends of M. A. C. The campaign was definitely launched at the Commencement Alumni Luncheon and subscriptions amounting to $35,000 were made at that time which very firmly established the project. During the coming year the organization work and a complete campaign of the alumni and student body will be made with a goal of $150,000 in view for a Union Memorial Hall.

Respectfully submitted,

C. W. McKIBBIN,
Alumni Recorder.

East Lansing, June 30, 1919.

REPORT OF THE STATE INSPECTOR OF ORCHARDS AND NURSERIES

To the State Board of Agriculture.

Gentlemen—In some respects the work of this department has been simplified, as compared with past years, by the fact that orchard insects and diseases have been less troublesome than usual. This has been due in part to the fact that owing to the severe winter of 1917-18 a very large proportion of the peach trees have been removed, which has lessened the number of cases of yellows and little peach. The same and other causes have lessened the ravages of the San Jose scale. In this case, however, not only have the host trees been destroyed, but the number of the insects have been reduced in part by the severity of the winter, and also by various parasites and by the unfavorable weather during the summer of 1917.

ORCHARD INSPECTION WORK.

The high prices obtained for the various fruits, as well as from the fact that the lessening of the number of the San Jose scale made them more hopeful of success, has led to increased attention to the orchards and greater interest in spraying. In many sections there are abandoned orchards in the neighborhood of young and healthy orchards, and since these orchards are generally infested with various dangerous insects and diseases we have had frequent calls to, have the trees either destroyed or given proper attention.

WHITE PINE BLISTER RUST CONTROL.

The cooperative agreement with the Federal Department of Agriculture relating to the scouting for trees infected with the White Pine Blister Rust has been continued.

During July, August and September, a half dozen or more inspectors under the direction of and paid by the Department of Agriculture, covered a considerable portion of the State, especially along the eastern and western sides, but were not able to find any indication of the presence of the disease, either in five-leafed pines, currants or gooseberries.

Early in April, 1919, the work was again taken up, and within a few days the disease was found in a white pine in Oakland County which had been purchased several years ago from one of the nurseries in which the disease was found in 1918. Fortunately the disease had not developed spores and it is hardly likely that is has spread to any of the Ribes in the vicinity. Thus far the blister rust has only been found in two nurseries in Oakland county, and in trees on two places which had been sold by one of these nurseries. Careful examination of the ribes in the vicinity of where the infected trees were found has failed to show any indication that the diease had spread from the infected pines.

At this time the blister rust has spread over the greater part of New England, and through the eastern and northern portions of New York, and has obtained a good foothold in Wisconsin and Minnesota, besides having been found in southeastern Pennsylvania, New Jersey and Ohio. It is fortunate for the forest and fruit interests of Michigan, as well as for the nurseries, that the Federal government was so prompt in starting eradication measures.

THE BARBERRY CAMPAIGN.

As was stated last year we also have a cooperative arrangement with the Bureau of Plant Industry of the U. S. Department of Agriculture for the eradication of barberry bushes which harbor the black-stem-rust of wheat. This includes not only the green and purple leaved forms of the common barberry (*Berberis vulgaris*), but several other species, including *Berberis Canadensis, B. Sinensis, B. ilicifoiium* and *B. aquifolium* or mahonia, besides some twenty other species which have been little planted in Michigan.

Although under the agreement, the scouting was to be done by the Department of Agriculture, owing to the failure of the appropriation bills, very little was done by its inspectors during the summer and in order that the barberries might be located and destroyed as soon as possible, two of the regular inspectors of this department were assigned to barberry inspection when they could be spared from other duties, and three others were specially employed for the work during July, August and September. Later on, the department of Agriculture put on a force of seven to ten men. The winter was unusually favorable for the work and it was continued with little interruption, with the result that when spring opened all of the cities and larger towns had been scouted, and many of them had been covered a second time, to make sure that all had been found and removed.

In addition to very large numbers in the parks, cemeteries and private grounds which were removed and no report made, before the regular canvass began, barberries were located by the inspectors on over 1,000 places in the city of Detroit alone, and the number reported by them was nearly 150,000. Several of the smaller cities had even more in proportion to the number of homes.

With very few exceptions the owners removed them promptly when the object was explained, and thanks to the excellent publicity given the matter by Dr. Coons, who had charge of the work for the U. S. Department of Agriculture, this was very generally understood, although a considerable number were not able to distinguish the dangerous species.

ORCHARD SPRAYING AND DUSTING.

In years when wet weather prevails as the buds on fruit trees are opening, many complaints have been received that the fruit is scabby even though the trees were sprayed following the usual formulas. The opinion has been that if the trees had received the dormant spray for scale the second application might be given at any time while the trees were in blossom. The spores of the apple scab pass the winter in the leaves upon the ground and if the weather is favorable are likely to infect the new leaves and blossom buds very soon after they develop. For this reason it is unsafe to delay the so-called "pink" spray until the blossoms are ready to open as is so often practiced. On the other hand, the only safe way is to make use of what has been called a "pre-pink" application. At the time the flower buds begin to separate in the clusters the leaves have commenced to develop and unless the trees are sprayed there is danger that both leaves and buds may become infected, especially in wet seasons.

WEATHER FORECASTS FOR SPRAYING.

Particularly when the rains continue for a number of days it is highly important that the trees be covered with a fungicide previous to a rain as otherwise the spores will have time to deveolp and infect the leaves and buds. In order that notice of a rain might be furnished to fruit growers arrangements were made with Mr. D. A. Seeley, Director of the Michigan Weather Service of the U. S. Department of Agriculture, at East Lansing, for special weather forecasts with a notice of impending storms three or four days in advance. These reports were sent to this office each morning in advance of the regular weather reports, during the spraying season. Owing to the local character of the storms during much of the spraying period the results were not as satisfactory as they otherwise would have been.

Plans were made to send out notice of the storms by telegraph to the various fruit growing sections where the word was distributed over the telephone and through the local papers, making it possible to protect the leaves and fruit from attack during rainy period.

Trees that were sprayed at the "pre-pink" stage were quite free from the attack of scab while those that did not receive the fungicide until late in the pink period were quite badly infected. Had the weather been wet during the two or three weeks following the setting of the fruit serious harm would have resulted where a primary infection had taken place.

The benefits from the special weather forecast seemed to be so large that is is planned to extend the service another season and cover a very large proportion of the leading Michigan apple districts.

THE DUSTING OF ORCHARDS.

Several of the largest fruit growers in Michigan have substituted the use of dust for the spraying of their orchards and thus far most of them feel well satisfied with the results. One advantage comes from the very marked saving of time as two men with one outfit are able to dust from 40 to 100 acres of bearing trees in eight hours, the number of acres of course varying with the size of the trees. As a consequence, it is often possible to cover an orchard with a combined fungicide and insecticide at the proper time when it would not be possible to do so with a spray rig, unless the number was made two or three times as many as would be needed of dusting machines. It is also possible to use the dusting machines in the orchard at night, which in fact is the very best time for the work and the dust may be applied when the trees are wet, or even when there is a light mist; which of course, would not be desirable conditions for spraying.

As opposed to dusting is the matter of cost of materials, which is considerably in favor of spraying, especially if a combined insecticide and fungicide is used. The question of cost however, would not be considered to any great extent provided the results are in favor of the dusting. In this regard it may be said that the results where dust has been used have been very satisfactory so far as injury to the foliage and fruit is concerned. Using the ordinary mixture with approximately 85 per cent of sulphur, and 15 per cent of arsenate of lead, injury is practically unknown; while with lime-sulphur solution at the rate of one gallon to forty and with one pound of arsenate of lead serious injury has often occurred, particularly if the application has been made while the trees were wet, or when the application is followed by several hot days.

The chewing insects are certainly as well controlled by the dusting of the trees as by the use of the spray. And, in ordinary seasons when there is comparatively little injury from apple scab, it has been possible to control it by means of dusting. However, in some sections where rain- have been frequent and conditions have been favorable for the develops ment of the apple scab, the results from the use of dust have not been as satisfactory as those from spraying.

It has been pretty well established that the effects of the dust are not as lasting as those of liquid applications; and hence we may infer that to secure equally good results it will be necessary to use the dust at more frequent intervals. Especial care should also be taken to cover the trees just before a storm.

Thus far, although the dust apparently serves to hold the brown rot and scab of stone fruits in check, it has not been conclusively shown that the various leaf-spot diseases can be controlled with equal certainty. From the fact that the dust may be used with safety upon the foliage of peaches and Japanese plums, and since it serves so well to prevent the scab and brown rot, it would seem that dusting machines certainly have their place in peach orchards. They should also be of use in cherry orchards where it is sometimes necessary to make use of a fungicide a few days before the crop is ripe when a liquid application would be liable to spot the fruit.

THE CONTROL OF PEACH LEAF CURL.

The past spring had weather conditions which were very favorable to the development of the disease which causes the leaves of peach trees to thicken and roll and to which the name peach leaf-curl has been given. As is generally understood, this is a fungus disease for which a cold, wet spring is especially favorable. When the weather is warm and dry little or no harm results. Nearly thirty years ago the writer demonstrated that the disease could be controlled by spraying; and, that to secure good results it was necessary to make the application very early in the spring, even before the buds have commenced to swell, and at least three weeks before the trees blossom. Careful experiments also showed that the spraying might be done in the fall with practically as good results, provided the leaves had dropped so that all parts of the trees could be reached. Open periods in the winter could also be utilized for spraying peach orchards, except that care was required not to allow the water in the rigs to freeze. Care also must be taken only to spray on days when the moisture would evaporate before it has time to freeze.

Either Bordeaux-mixture, copper sulphate solution at the rate of one to two pounds in fifty gallons of water, or lime-sulphur solution (diluted 1 to 15) if applied at the proper time will prevent the development of this disease. The dormant strength of lime-sulphur solution as used for San Jose scale would also be effectual against the peach leaf curl.

Many of the best peach growers of Michigan who have usually kept their trees free from leaf-curl suffered seriously from the disease in 1919. They had planned to spray their trees and supposed there would be ample time; but, during the month of March it was so wet in most orchards as to make it practically impossible to get around with spray rigs. During the last few days of the month, the weather was unusually warm for the season which resulted in the swelling of the leaf-buds so that very little effect was secured when the spraying was done during the first half of April. On the un-

sprayed and late sprayed trees practically all of the leaves were attacked and dropped. This resulted in a very serious loss of the peach crop. Where the trees were thoroughly sprayed one week before the buds swelled there was little or no loss of foliage or fruit.

ORCHARD AND NURSERY LEGISLATION.

In connection with the campaign for the eradication of barberries some difficulty was experienced from the fact that the original law merely provided for the destruction of trees and shrubs infected with a dangerous disease. During the summer months it was a comparatively easy matter to find infected leaves upon nearly every barberry bush, but during the winter it was not possible to find the infection, so that the period in which the campaign could be carried on, except at the sufferance of the owners, covered only about one-half of the year. The Federal Government through the U. S. Department of Agriculture had put on a quarantine against the shipment of practically all barberries and mahonias, except the Japanese, into the Central Western States in which barberry eradication campaigns had been carried on. The legislatures of these States in the spring of 1919 passed laws forbidding the growing or sale within the respective States of any of the dangerous species of barberries and mahonias.

House Enrolled Act No. 31 of the Michigan Legislature, Section 17a, makes it unlawful for any person to keep upon his premises any of the barberries, except *Berberis Thunbergii* or *Berberis Japonica.*

Another provision of the same act makes it possible to take prompt action in case any dangerous insect or disease not found in the State is brought in from outside. Besides conferring authority to destroy trees and plants which have been attacked by insects or diseases, it is now possible to destroy trees and plants which may not be actually infested but the destruction of which is necessary in order to eradicate the insects and diseases. This provision will be especially helpful in case the gypsy or brown-tail moths or the European corn borer make their appearancein Michigan.

Under this law, provided it becomes necessary to destroy trees and plants which have not become infested, the owners are to be recompensed for the value of the trees, plants, etc.

INSPECTION OF MICHIGAN NURSERIES.

The acreage of fruit nursery stock has for several years shown a considerable decrease but there has been approximately as large an increase in the acreage of small fruit plants and ornamentals, all of which have been inspected. Owing to the war conditions, the importation of trees and shrubs from Europe has been greatly decreased, especially in the way of azaleas, rhododendrons, and other stock designed for forcing in greenhouses which formerly came from Belgium and Holland in very large numbers. The importation of fruit stocks from France has been practically as large as in previous years, and it arrived in much better condition than in 1918.

Beginning with July 1, 1919, a Federal Quarantine will prevent the importation of trees and shrubs from foreign countries, except fruit trees and rose stocks. Provision however, has been made for bringing in new and rare plants for trial. The object of the quarantine is to keep out

dangerous insects and diseases. It was especially aimed to keep out trees and shrubs which are brought in with balls of earth upon the roots. These frequently contain a number of dangerous insects which cannot be detected by the most careful inspection unless the earth is washed from the roots and carefully examined. This would be fatal to the trees.

The condition of the Michigan nursery stock, and of that imported from Europe has never been better, showing greater attention to the control of insects and diseases on the part of both Michigan and European nurserymen.

We append to this report a list of the Michigan nurseries which have taken out a license, and whose stock has passed inspection; and also of Michigan dealers in nursery stock, and nurserymen in other states, who have taken out licenses to sell nursery stock in Michigan. All of these parties have filed certificates showing their nursery stock has passed inspection.

LICENSED MICHIGAN NURSERIES, 1918-1919.

Alferink, Albert, Holland.
Allis & Hood, Adrian.
Asman, C. W., Port Huron.
Augustine & Co., Normal, Ill.
Baldwin, O. A. D., Bridgman.
Bashford, C. L., Mason.
Basswood Center Nurseries, Stevensville.
Behnken, J. H., Somerset Center.
Bliss, A. W., Harbor Springs.
Boehringer Brothers, Bay City.
Bohl, William, Buchanan.
Breitmeyer Landscape & Nursery Co., The, Detroit.
Bridgman Nursery Co., Bridgman.
Brooks Co., J. C., Detroit.
Brown, D. M., Grand Rapids.
Burgess Seed and Plant Co., Galesburg.
Campbell, Chester G., Paw Paw.
Celery City Nurseries, Kalamazoo.
Cole, Levant, Battle Creek.
Collins, Ward E., Fennville.
Coryell Nursery, The, Birmingham.
Cukerski, Wencel L., Grand Rapids.
Curtis, L. T. & Son, Flint.
Cutler & Downing, Benton Harbor
Daly, Thos. W., Watervliet.
Dunham, Enos W., Baroda.
Dutton, Chas. H., Holland.
Ellis, Daniel H., Saginaw.
Emlong & Sons, Stevensville.
Ferrand, E. & Sons Company, Detroit.
Fetters, Thos. J., Harbor Springs.
Flansburgh, C. N. & Son, Jackson.
Frissel, Martin, Muskegon.
Ganzhorn, Jacob, Ann Arbor.
Gill, Mrs. Bertha M., Ypsilanti.
Glenwood Nurseries, The, Holland.
Greening Nursery Co., Monroe.
Gobleville Nurseries, Gobleville.
Gustin, Chas. F., Adrian.
Hamilton, A. & Sons, Bangor.
Hampton, J. E., Bangor.
Hanes, Peter, Farmington.
Havekost, Geo. H., Monroe.
Hawley, Geo. A., Hart.
Helmer Farm Nursery, Battle Creek.
Hemingway, Geo. R., Oak Park, Ill.
Hibbler, E. B., Detroit.
Ilgenfritz, Sons' Co., I. E., Monroe.
Insulinde Nurseries, Kalamazoo.
Jeffrey & Son, James, Kalamazoo.
Kalamazoo Nurseries, Kalamazoo.
Kalle Brothers, South Haven.
Katzenberger, Valentine, Fosters.
Keith Bros. Nursery, Sawyer.
Kellogg Co., The R. M., Three Rivers.
Kleinhans Floral Co., D., St. Louis
Knight & Son, David, Sawyer.
Marvin, O. F., Holton.
Mayer, Jr., Michael, Merrill.
Michigan Nursery Co., Monroe.

Merrill, W. F., South Haven.
Miller, Abner, Bravo.
Mutual Nurseries Co., Monroe.
Nash, C. C., Three Rivers.
Nelson & Son, J. A., Paw Paw.
Newell, Reuben, Hi hland Park.
Nieb, Daniel P., Niles.
Niles Nursery Co., The, Niles.
Nu-way Nurseries, Lansing.
Orchard Lake Nurseries, Orchard Lake.
Owens, Geo. B., Leslie.
Pindar, Joseph, Detroit.
Pitcher, W. D., Buchanan.
Pontiac Nursery Company, Detroit.
Potter, E. W. Leslie.
Prestage, J. G., Allegan.
Prudential Nursery Co., Kalamazoo.
Quandt, Elmer, Dearborn.
Rasmussin, R. J., Marlette.
Rhodes, Alice A. & Nettie M., Jackson.
Rice, Miss Greta B., Port Huron
Roche, Mr. John C., Battle Creel
Rokely, J. N., Bridgman.
St. Joseph Nursery, The, St Joseph.
Saier, Harry E., Lansing.
Schenck, Geo. H., Elsie.
Schild, H. J., Ionia.
Shepard, Chas E., Bangor.
Smith, Henry, Grand Rapids.
Spielman Brothers, Adrian.
Sweet, L. H. Carsonville.
Taft, H. A., South Haven.
Tindall, W. F., Boyne City.
Ward, Paul L., Hillsdale.
Weller Nurseries, Holland.
Weston, A. R. & Co., Bridgman.
Whitten, C. E., Bridgman.
Williams Brothers, Bridgman.
Witbeck, F. M. & Son, Millburg.
Wolcott Nurseries, Jackson.
Wolverine Detroit Nurseries, Detroit.

LICENSED DEALERS IN NURSERY STOCK, 1918-1919.

Asman & Dunn, Detroit.
Benton Harbor Nursery Co., Benton Harbor.
Boyd, Joseph B., Traverse City.
Buskirk, C. M., Big Rapids.
Cross, Eli, Grand Rapids.
Crowley-Milner Company, Detroit
Derrickson, Henry, Coldwater.
Detroit Shade Tree Co., Detroit.
Filer, A. C., Mt. Clemens.
Freyling & Mendels, Grand Rapids.
Fox, A. W., Coldwater.
Gibson & Son, S. B., Detroit.
Grand Rapids Nursery Co., Grand Rapids.
Grohman, the Florist, Saginaw.
Hallman, W. S., Coloma.
Hotchkiss, Caleb, Detroi .
Hudson, Co., J. L., Detroit.
Hughes, Chas. P., Hillsdale.
Husted & Co., N. P., Lowell.
Ilgenfritz, E. C., Detroit.
Isbell & Co., S. M., Jackson.
Jones', Sons & Co., J. R., Kalamazoo.
Knapp Company, J. R., Lansing
Knapp, W. F., Monroe.
Knoch, Mrs. Gus, Detroit.
Kresge Co., S. S., Detroit.
Lohrman Seed Co., Detroit.
Mountain Home Cemetery, Kalamazoo.
Nelson, C. A., Northport.
Oakland Gardens Nursery, Detroit.
Peterson, George, Escanaba.
Powers & Co., Battle Creek.
Pult, Casper J., Detroit.
Rayl Co., T. B., Detroit.
Smith & Co., E. M., Detroit.
Steffer, Reinhold W., Bay City.
Stover, F. J., Traverse City.
Strittmatter, Adolph, Detroit.
Trankla & Co., Chas., Grand Rapids.
Tribolet Co., The, Coldwater.

Valley City Nurseries, Grand Rapids.
Van Aken Bros., Coldwater.
Van Bochove & Brother, C., Kalamazoo.
Vogt & Son, David, Coldwater.
Von Boeslager, August, Mount Clemens.
Walther's Department Store, Bay City.
Webb & Co., D. S., Traverse City.
Westgate Nursery Co., H. L., Monroe.
Wise, Ralph, Plainwell.
Woolworth & Co., F. W., Buffalo, N. Y.

LICENSED FOREIGN NURSERIES, 1918-1919.

Allen Nursery Co., Rochester, N. Y.
Bogue, Dewane, Batavia, N. Y.
Brow Nursery Co., F. W., Rose Hill, N. Y.
Brown Brothers Co., Rochester, N. Y.
Bryant, Arthur & Son, Princeton, Ill.
Bryant Brothers, Dansville, N. Y.
Burr & Co., C. R., Manchester, Conn.
Central New York Nursery Co., Geneva, N. Y.
Charlton Nursery Co., Rochester, N. Y.
Chase Nurseries, The, Geneva, N. Y.
Chase Brothers Co., Rochester, N. Y.
Dreer, Henry A., Inc., Philadelphia, Pa.
Emmons & Co., Newark, N. Y.
Fairview Nurseries, The, Rochester, N. Y.
Farmers' Nursery Co., Troy, O.
First National Nurseries, Rochester, N. Y.
Fruit Growers' Nurseries, Newark, N. Y.
Graham Nursery Co., Rochester, N. Y.
Grover & Co., Frederick E., Rochester, N. Y.
Guaranty Nursery Co., Rochester, N. Y.
Harman Nursery Co., Inc., M. H., Geneva, N. Y.
Hawks Nursery Co., Wauwatosa, Wis.
Heath & Co., Manchester, Conn.
Hooker Brothers, Rochester, N. Y.
Howe-Campbell Nursery Co., Rochester, N. Y.
Huntsville Wholesale Nurseries, Huntsville, Ala.
Jewell Nursery Co., Lake City, Minn.
Knight & Bostwick, Newark, N. Y.
La Pointe Nursery Co., Geneva, N. Y.
Moon Co., Wm. H., Morrisville, Penn.
Moore & Co., Wm. C., Newark, N. Y.
Nelson & Sons, Swain, Chicago, Ill.
Pennsylvania Nursery Co., Girard, Pa.
Perry Nursery Co., Rochester, N. Y.
Rice Brothers Co., Geneva, N. Y.
Sonberegger Nursery & Seed House, Beatrice, Neb.
Stark Nurseries and Orchards Co., Louisiana, Mo.
Stewart & Co., C. W., Newark, N. Y.
Taylor & Co., H. S., Rochester, N. Y.
Walton, Cary A., Greenfield, Ind.
Weeks Nursery Co., Inc., C. H., Lyons, N. Y.
Western New York Nursery Co., Rochester, N. Y.
Westminster Nursery, The, Westminster, Md.
Wisconsin Nurseries, Union Grove, Wis.

Respectfully submitted,
L. R. Taft,
State Inspector of Nurseries and Ordhards.

East Lansing, June 30, 1919.

REPORT OF INSECTICIDE AND FUNGICIDE INSPECTION.

ANDREW J. PATTEN AND PERCY O'MEARA.

To the State Board of Agriculture:

During the year 1919, 74 samples of insecticide and fungicides have been collected and analyzed. The results are presented herewith.

LIME-SULPHUR SOLUTIONS AND SUBSTITUTES.

Six samples of lime-sulphur solution and a like number of the dry compound of lime and sulphur were collected. One sample of sodium sulfide solution and two of dry sodium sulfide also one sample of barium sulfide ("B T S") were analyzed. The results of analysis are given in the following tables. Attention is called to the last column in the table where is given the amount of calcium polysulfide equivalent to the total sulfide sulphur found. This affords a convenient means of comparing the probable efficiency of the various samples.

LIME SULPHUR COMPOUNDS.

—SOLUTIONS—

No.	Manufacturer.	Baume Found.	Baume Guaranteed.	Total Sulphur. Found. %	Total Sulphur. Guaranteed. %	Calcium Polysulfide. %
434	Dow Chemical Co., Midland, Mich.	32.50	33	25.05	25.0	29.96
449	Imperial Chemical Co., Grand Rapids, Mich.	32.5	....	25.03	23.0	30.05
460	San-O-Cide Spray Co., Fennville, Mich.	33.0	32	25.95	25.0	31.10
468	South Haven Chemical Co., South Haven, Mich.	32.5	32	24.38	25.0	29.86
470	T. W. Daly, Sister Lake, Mich.	30.0	....	18.53	....	19.81
471	*Grasselli Chemical Co., Cleveland Ohio*	*32.5*	33	*24.82*	*25.0*	*30.26*

DRY PREPARATIONS.

No.	Manufacturer.	Baume Found.	Baume Guaranteed.	Total Sulphur. Found. %	Total Sulphur. Guaranteed. %	Calcium Polysulfide. %
447	Detroit White Lead Works, Detroit, Mich.	....	....	58.07	....	67.37
452	Detroit White Lead Works, Detroit, Mich.	....	....	50.46	....	55.50
451	Sherwin-Williams Co., Cleveland, Ohio	....	....	56.35	....	62.06
461	Sherwin-Williams Co., Cleveland, Ohio	....	....	57.22	....	62.37
808	Sherwin-Williams Co., Cleveland, Ohio	....	....	61.04	....	69.06
803	Dow Chemical Co., Midland, Mich.	....	....	62.76	....	67.31

SOLUBLE SULPHUR COMPOUNDS OTHER THAN LIME-SULPHUR.

No.	Name and Manufacturer.	Baume. Found.	Baume. Guaranteed.	Total. Sulphur. Found. %	Total. Sulphur. Guaranteed. %	Calcium. Polysulfide Equivalent. %
199	Sulfocide—B. G. Pratt Co., New York City	41	....	30.94	30.0	36.34
446	Soluble Sulphur Compound, Niagara Sprayer Co., Middleport, N. Y.	....	....	58.04	....	63.75
462	Soluble Sulphur Compound, Niagara Sprayer Co., Middleport, N. Y.	....	....	55.13	....	49.14
801	B. T. S.—General Chemical Co., New York, N. Y.	....	....	42.16	....	47.63

ARSENATE OF LEAD.

Six samples of arsenate of lead paste and nine of the powder form were analyzed. All of the samples contained the required amount of arsenic oxid and were above the guarantees made by the manufacturers. Likewise all samples were well under the guarantees for soluble arsenic oxid. One sample, No. 429, contained water in excess of the legal standard.

ARSENATE OF LEAD (Paste)

No.	Manufacturer.	Moisture.	Lead Oxid. (PbO)		Arsenic Oxid (As_2O_5)			
					Total.		Soluble.	
			Found.	Guar.	Found.	Guar.	Found.	Guar.
		%	%	%	%	%	%	%
429	Ansbacher Insecticide Co., New York, N. Y.	51.02	30.80	35.0	15.72	15.0	0.18	0.50
431	Dow Chemical Co., Midland, Mich.	44.50	33.20	....	18.10	15.0	0.31	0.50
197	Grasselli Chemical Co., Cleveland, Ohio	36.10	40.71	....	19.71	15.0	0.08	0.50
455	Grasselli Chemical Co., Cleveland, Ohio	46.50	34.30	....	16.80	15.00	0.11	0.50
467	Grasselli Chemical Co., Cleveland, Ohio	44.23	36.47	....	17.07	15.00	0.15	0.50
426	Toledo Rex Spray Co., Toledo, Ohio	47.50	33.69	32.00	16.83	15.00	0.15	0.75

ARSENATE OF LEAD (Dry Powder).

No.	Manufacturer.	Lead Oxid. (PbO)		Arsenic Oxid (As^2O^5)			
				Total.		Soluble.	
		Found.	Guar.	Found.	Guar.	Found.	Guar.
		%	%	%	%	%	%
464	Corona Chemical Co., Milwaukee, Wis.	63.96	....	32.15	30.0	0.34	0.75
807	Corona Chemical Co., Milwaukee, Wis.	65.42	....	32.80	30.0	0.13	0.75
443	Detroit White Lead Works, Detroit, Mich.	64.46	....	31.05	....	0.23	....
809	Dow Chemical Co., Midland, Mich.	64.83	....	30.00	30.0	0.46	1.00
456	Grasselli Chemical Co., Cleveland, Ohio	63.98	....	32.05	31.0	0.49	0.75
423	Riches-Piver & Co., New York, N. Y.	62.70	....	31.70	30.0	0.49	1.00
465	Sherwin-Williams Co., Cleveland, Ohio	64.56	....	30.70	30.0	0.14	1.00
469	Toledo Rex Spray Co., Toledo, Ohio	64.36	62.0	31.90	31.0	0.52	1.00
804	Toledo Rex Spray Co., Toledo, Ohio	64.02	62.0	31.90	31.0	00.57	1.00

CALCIUM ARSENATE.

Six samples of calcium arsenate and one sample of magnesium arsenate are included in the next table. Three samples, Nos. 484, 802, 805, contained less total arsenic oxid than guaranteed and two samples, Nos. 482 and 805 contained more soluble arsenic oxid than guaranteed.

CALCIUM ARSENATE.

No.	Manufacturer.	Calcium Oxid. (CaO)	Arsenic Oxid (As_2O_5).			
			Total.		Soluble.	
			Found.	Guar.	Found.	Guar.
		%	%	%	%	%
482	Corono Chemical Co., Milwaukee, Wis.	47.40	47.80	42.6	1.87	1.50
806	*Corona Chemical Co., Milwaukee, Wis.*	49.45	46.75	43.5	0.34	1.50
445	Detroit White Lead Works, Detroit, Mich.	42.50	44.75	41.4	0.92	4.1
484	The Glidden Co., Cleveland, Ohio	41.10	43.40	46.0	0.45	1.50
419	*Riches-Piver Co., New York, N. Y.*	*46.95*	*41.00*	*40.0*	*0.43*	*0.4*
802	Toledo Rex Spray Co., Toledo, Ohio	45.00	38.30	41.4	0.24	1.50
805	Magnesium Arsenate, Dow Chemical Co., Midland, Mich.	....	32.13	33.0	1.25	0.75

PARIS GREEN.

Five samples of Paris Green and one sample of "Bug Finish", (a mixture consisting of about 90 parts gypsum and 10 parts Paris green) were analyzed. All of the samples were satisfactory as regards total and soluble arsenious oxid. *Two samples No. 425 and 430 were found to be slightly* under weight.

PARIS GREEN.

No.	Manufacturer.	Weight.		Arsenious Oxid (As_2O_3) Total.		Arsenious Oxid (As_2O_3) Soluble.		Copper Oxid. (Cu O)
		Found.	Guar.	Found.	Guar.	Found.	Guar.	
		oz.	oz.	%	%	%	%	%
425	DeVoe & Reynolds, New York, N. Y.	7.75	8	55.7	50.0	1.68	3.50	30.0
450	Imperial Chemical Co., Grand Rapids, Mich.	4.73	4	56.3	50.0	2.47	3.50	30.3
428	Fred L. Laveneburg, New York, N. Y.	4.31	4	55.5	50.0	1.88	3.50	29.7
422	Nitrate Agencies Co., New York, N. Y.	16.00	16	53.85	50.0	1.76	3.50	30.3
430	Nitrate Agencies Co., New York, N. Y.	7.66	8	54.00	50.0	1.83	3.50	28.8
479	Bug Finish, Michigan Gypsum Co., Grand Rapids, Michigan	....	....	0.58	0.5	0.3	0.35	0.3

BORDEAUX MIXTURES.

Six samples of Bordeaux mixture were collected all of which were found to be equivalent to guarantee in respect to the amount of copper. Samples No. 418 and 466 were guaranteed to contain 16 oz. net weight but were found to contain 11.1 oz. and 15.6 oz. respectively.

BORDEAUX MIXTURES.

No.	Manufacturer.	Water.	Copper (Cu). Found.	Copper (Cu). Guar.
		%	%	%
463	Corona Chemical Co., Milwaukee, Wis.	....	11.98	11.0
442	Detroit White Lead Works, Detroit, Mich.	....	12.36	11.0
457	Grasselli Chemical Co., Cleveland, Ohio	51.50	9.65	7.5
437	Nitrate Agencies Co., New York, N. Y.	58.40	7.20	....
418	Riches-Piver Co., New York, N. Y.	....	10.25	12.50
466	Sherwin-Williams Co., Cleveland, Ohio	....	12.04	11.0

BORDEAUX-ARSENATE MIXTURES.

Eight samples of this class were obtained and the analyses appear in the following table.

All of the samples fulfilled the guarantees made by the manufacturers Sample No. 473 contains 39.75% lime (CaO) and No. 441 contains 74.41% sulphur.

For a more complete discussion of this class of goods the reader ir seferred to Special Bulletin No. 96 published in May 1919.

BORDEAUX-ARSENATE MIXTURES.

No.	Manufacturer and Name.	Water.	Arsenic (As) Total. Found.	Arsenic (As) Total. Guar.	Arsenic (As) Soluble. Found.	Arsenic (As) Soluble. Guar.	Copper (Cu). Found.	Copper (Cu). Guar.	Lead Oxid. (P b D)
		%	%	%	%	%	%	%	%
	"Ansbacher Insecticide Co., New York, N. Y..								
435	"Adheso Green Label"	53.33	6.77	5.50	0.12	0.50	3.88	3.90	22.8
476	"Adheso Green Label"	56.90	6.32	5.50	0.04	0.50	3.93	3.90	20.6
436	"Adheso Orange Label"	57.90	6.28	....	0.09	....	2.60	....	20.4
	Bowker *Insecticide Co., Boston, Mass*								
472	"Pyrox	60.25	5.18	3.42	0.05	0.75	2.43	1.50	15.95
477	"Pyrox"	62.75	4.85	3.42	0.07	0.75	2.07	1.50	15.60
481	"Pyrox"	55.50	5.84	3.42	0.07	0.75	2.89	1.50	18.20
	H. J. Smith, Utica, N. Y.								
473	"Smith's Hexpo"	....	11.48	12.9	0.15	1.00	5.19	6.00	18.54
	Niagara Sprayer Co., Middleport, N. Y.								
441	Niagara Potato Mixture	....	2.15	1.95	0.15	0.50	1.73	1.50	1.73

TOBACCO PRODUCTS.

Only three samples were obtained this year. Two of these were found to be slightly below the guarantee for nicotine made by the manufacturer. The amount of deficiency is probably not sufficient to impair their efficiency as insecticides.

TOBACCO PRODUCTS.

No.	Manufacturer and Name.	Nicotine. Found.	Nicotine. Guar.
		%	%
	Kentucky Tobacco Products Co., Louisville Co., Louisville, Ky.		
432	"Black Leaf 40"	38.8	40.0
454	"Nico-Fume Liquid"	39.6	40.0
	Niagara Sprayer Co., Middleport, N. Y.		
439	"Tobacco Dust"	0.58	......

SMUT REMEDIES.

Five samples of proprietary mixtures of formaldehyde solution prepared for grain treatment against smut were analyzed. The percentage of formaldehyde was found to vary from 24.9 to 30.6 per cent. The ordinary commercial formaldehyde solution (formalin) should contain 36.8 per cent formaldehyde.

SMUT REMEDIES

No.	Manufacturer and Name.	Formaldehyde. Found.	Formaldehyde. Guar
		%	%
	Albion Chemical Works, Albion, Mich.		
475	"Bud's Smuticide"	34.6	....
	Anti Smut Chemical Co., North Adams, Mich.		
424	"Anti Smut"	24.9	....
812	"Anti Smut"	25.2	28.0
	Chemical Research Co., Kalamazoo, Mich..		
448	"The Original Smut Killer"	31.0	....
478	"The Original Smut Killer"	30.6	....
	Dr. Lape Veterinary Co., Inc., Adrian, Mich.		
417	"Smutene"	30.4	35.0
818	"Smutene"	29.8	35.0

MISCELLANEOUS MATERIALS.

421
480 Bug Death, manufactured by Danforth Chemical Co., Leominster, Mass. Guaranteed to contain Zinc Oxid 47%, Lead *Oxid 5%.*

Results found:

No. 421, Zinc Oxid	43.60%
No. 421 Lead Oxid	11.40%
No. 480 Zinc Oxid	49.40%
No. 480 Lead Oxid	9.15%

200 Hammond's Slug Shot, Manufactured by Hammond Slug Shot Works, Beacon, N. Y. Guaranteed to contain Sulphur 6%, Copper Sulfate 1%, Nicotine, trace, Copper Arsenite 1.50%, Crude Carbolic Acid 0.40%, Inert Ingredients 91%.

Results found:

Arsenic (as Metallic)	0.88%
Soluble Arsenic (as Metallic)	0.09%
Copper (Cu.)	0.34%
Sulphur	5.76%

811 Arsenate of Zinc, Manufactured by the General Chemical Co., New York, N. Y. Guaranteed to contain Total Arsenic (a *Metallic) 30.5%, Soluble Arsenic (as Metallic) not more than 1%.*

Results found:

Arsenic (as Metallic)	31.46%
Soluble Arsenic (as Metallic)	0.18%
Zinc Oxid (ZnO)	52.88%

810 Niagara Dusting Sulphur, Manufactured by the Niagara Sprayer Co. Middleport, N. Y. Guaranteed to contain Sulphur 93%.

Results found:

Sulphur	92.64%

440 Niagara 3 in 1 Dusting Mixture, Manufactured by the Niagara Sprayer Co., Middleport N. Y. Guaranteed to contain Sulphur not less than 49%, Nicotine 0.20%, Total Arsenic not less than 1.95%, Soluble Arsenic not over 0.50%.

Results found:

Sulphur	51.80%	
Total Arsenic	3.40%	As^2O^5
Soluble Arsenic	0.51%	As^2O^5
Lead Oxid	5.14%	
Nicotine	0.25%	

444 Niagara 90-10 Mixture, Manufactured by the Niagara Sprayer Co., Middleport, N. Y. Gauranteed to contain Sulphur not less than 88%, Total Arsenic not less than 1.95%, Soluble Arsenic, not over 0.50%.

Results found:

Sulphur	89.62%	
Total Arsenic	3.40%	As^2O^5.
Soluble Arsenic	0.10%	As^2O^5.
Lead Oxid	6.04%	

453 Cut-Worm Killer, Manufactured by the Sterling Chemical Co., Cambridge, Mass. Guaranteed to contain not less than 1% Arsenious Oxid nor more than 0.07% Water Soluble Arsenious Oxid, Weight 1 lb.

Results found:

Total Arsenious Oxid (As^2O^3)	1.12%
Net weight found	12.4 oz.

East Lansing, June 30, 1919.

REPORT OF THE STATE INSPECTOR OF APIARIES.

To the Honorable, the State Board of Agriculture:

Following is the sixth annual report of the State Inspector of Apiaries *for the fiscal year ending June 30, 1919:*

SUMMARY OF INSPECTION WORK DURING THE YEAR.

Number of apiaries visited	630
Number of colonies inspected	5270
Number of colonies affected with American foul brood	536
Number of colonies affected with European foul brood	670

It is a very significant fact that for the fiscal year ending June 30, 1917 *nearly six times as much American foul-brood was found as European* foul-brood, while during the last year there has been found more European *foul-brood than American foul-brood.* This occurs because by a closer study of the European foul-brood it has been found that much of it assumes

the appearance of American foul-brood. At the present time laboratory diagnosis is just being started and from this we hope to gain much information in regard to the extremely variable symptoms of European foul-brood. In this respect our work is unique as apparently no other State Inspectors Office is making any laboratory study of the disease.

The recent legislature saw fit to amend the inspection law somewhat giving the State Inspector authority to quarantine districts where foul-brood is epidemic. Also the appropriation was increased from $3,000 to $10,160. With the increased resources, it is hoped that inspection service can be given to all who are in need of it.

On July 8, 1918, Mr. D. P. Barrett enlisted, thus leaving the office without an experienced deputy. Mr. D. L. Ulman was secured to complete Mr. Barrett's unfinished work. Mr. Barrett is again with this office in his usual capacity. Mr. R. H. Kelty began work as a deputy on July 1, 1918. Mr. Kelty is doing some inspection work, but is chiefly engaged in the bacteriological work referred to above.

Respectfully submitted,
B. F. KINDIG,
State Inspector of Apiaries

East Lansing, Mich., June 30, 1919.

REPORT OF THE DEPARTMENT OF METEOROLOGY.

President F. S. Kedzie, College.

Dear Sir—I have the honor to submit the following report on the work of this department for the school year just closed:

The usual course in meteorology was conducted during the spring term, thirteen students being enrolled for the subject.

A course in meteorology was given to 54 students in the S. A. T. C. during the fall term of 1918.

Very respectfully,
D. A. SEELEY,
Instructor in Meteorology

East Lansing, June 30, 1919.

METEOROLOGICAL TABLES.

METEOROLOGICAL TABLES.

Monthly Meteorological Summary, Lansing, Michigan, July, 1918.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.	This month since 1863. Year.	Mean temperature.	Total precipitation.
							1863	....	....
1	65	48	56	0	Cloudy	21	1864	74.5	1.25
2	72	45	58	0.04	Cloudy	58	1865	65.6	3.91
3	84	57	70	0	Partly Cloudy	86	1866	71.7	4.19
4	88	60	74	0	Cloudy	52	1867	71.6	1.78
5	83	65	74	T.	Partly Cloudy	53	1868	77.2	1.11
6	78	55	66	0	Partly Cloudy	86	1869	70.4	5.77
7	71	49	60	0	Partly Cloudy	72	1870	74.4	8.02
8	76	44	60	0	Clear	100	1871	70.6	3.10
9	79	48	64	0	Cloudy	68	1872	74.9	3.36
10	73	55	64	0.21	Cloudy	36	1873	70.8	5.12
11	67	50	58	0.28	Cloudy	31	1874	72.0	2.56
12	78	50	64	0	Partly Cloudy	89	1875	69.7	2.42
13	81	50	66	0	Cloudy	81	1876	72.5	2.10
14	84	53	68	0	Partly Cloudy	100	1877	71.4	2.25
15	84	54	69	T.	Cloudy	67	1878	73.0	2.96
16	73	64	68	0.06	Cloudy	,5	1879	74.0	2.19
17	81	59	70	0	Partly Cloudy	67	1880	68.0	6.27
18	82	56	69	0	Partly Cloudy	66	1881	73.1	1.81
19	87	53	70	0	Clear	93	1882	67.5	2.32
20	92	59	76	0	Clear	99	1883	68.9	11.27
21	94	65	80	0	Clear	97	1884	68.0	2.60
22	85	64	74	T.	Cloudy	24	1885	72.7	2.52
23	93	66	80	T.	Partly Cloudy	62	1886	70.7	0.65
24	91	62	76	0	Cloudy	64	1887	75.5	1.50
25	92	71	82	T.	Partly Cloudy	85	1888	70.5	2.40
26	94	69	82	1.36	Partly Cloudy	73	1889	70.2	3.41
27	89	68	78	T.	Partly Cloudy	83	1890	71.1	0.92
28	93	62	78	0	Clear	100	1891	65.3	1.88
29	83	55	69	0.01	Partly Cloudy	45	1892	70.3	2.00
30	07	49	60	0	Partly Cloudy	55	1893	71.5	1.86
31	76	42	59	0	Clear	100	1894	73.2	0.86
							1895	70.5	1.47
							1896	71.8	6.73
							1897	73.8	8.49
Mean highest temperature						81.9	1898	70.0	1.34
Mean lowest temperature						56.4	1899	69.8	2.11
Mean temperature for month						69.2	1900	69.6	4.15
Total precipitation for month						1.96	1901	74.2	5.08
							1902	70.6	7.13
							1903	67.9	3.79
WEATHER							1904	69.2	1.97
							1905	69.8	5.75
							1906	70.8	2.23
Number days clear						6	1907	70.0	4.30
Partly cloudy						14	1908	7.32	1.03
Cloudy						11	1909	70.0	2.56
With 0.01 or more of precipitation						6	1910	71.0	1.53
							1911	71.3	1.65
							1912	69.6	5.06
SUNSHINE.							1913	70.8	2.85
							1914	71.0	1.65
							1915	67.9	5.17
Number hours sunshine						317.0	1916	76.1	0.09
Possible hours sunshine						464.9	1917	70.0	3.06
Percentage of possible						68	1918	69.2	1.96

BAROMETER—Mean, 30.02 inches; highest, 30.20 inches, on 4th; lowest, 29.74 inches, on 1st.

TEMPERATURE—Highest, 94°, on 26th; lowest, 42°, on 31st; greatest daily range, 34°, on 19th; least daily range, 9°, on 16th: normal for month, 70.9°; excess or deficiency this month, −1.7°; accumulated excess or deficiency since Janaury 1st, −344°; average daily, same period, −1.6°; highest in 33 years, 102°, lowest, 37°.

PRECIPITATION (in inches)—Total amount, 1.96; *normal*, 3.22; *excess or deficiency this month*, −1.26; *since January 1st*, −1.52; greatest amount in any 24 hour period, 1.36, on 26th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southwest; total movement, 2,971 miles; average hourly velocity, 4.0 miles; maximum velocity 17, from northwest of 1st.

DATES OF— Auroras, 0; fog, dense, 0; hail, 0; thunderstorms, 2, 23, 24, 26, 29; Halos: solar, 3, 4, 5, 8, 13; lunar, 0; frost: killing, 0; heavy, 0; light, 8, 31.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Michigan, August, 1918.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	80	47	64	0	Partly cloudy	98
2	75	50	62	0	Clear	71
3	73	45	59	0	Cloudy	44
4	89	54	72	0.04	Partly cloudy	52
5	97	65	81	0	Partly cloudy	85
6	102	73	88	0	Clear	95
7	98	70	84	0	Clear	69
8	92	65	78	0.04	Partly cloudy	53
9	75	60	68	T.	Cloudy	21
10	87	56	72	0	Partly cloudy	62
11	90	68	79	0.16	Partly cloudy	50
12	90	67	78	T.	Partly cloudy	52
13	96	75	86	0	Clear	100
14	84	59	72	0	Partly cloudy	65
15	85	54	70	0	Clear	94
16	73	61	67	0.03	Cloudy	0
17	80	58	69	0	Partly cloudy	97
18	82	52	67	0	Clear	100
19	83	50	66	0	Clear	100
20	87	61	74	0	Clear	97
21	92	66	79	0.11	Partly cloudy	54
22	89	68	78	0	Cloudy	57
23	92	68	80	0.25	Partly cloudy	43
24	86	61	74	0	Part cloudy	60
25	87	57	72	0	Partly cloudy	79
26	85	59	72	0	Cloudy	61
27	84	51	68	0	Partly cloudy	75
28	79	63	71	0.42	Cloudy	15
29	78	54	66	0	Clear	99
30	80	52	66	T.	Cloudy	47
31	72	50	61	0.39	Partly cloudy	59

Mean highest temperature	85.2
Mean lowest temperature	59.3
Mean temperature for month	72.2
Total precipitation for month	1.44

WEATHER

Number days clear	9
Partly cloudy	15
Cloudy	7
With 0.01 or more of precipitation	8

SUNSHINE.

Number hours of sunshine	285.9
Possible hors sunshine	430.7
Percentage of possible	66

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	3.00
1864	70.7	0.39
1865	65.8	3.38
1866	62.6	3.44
1867	69.8	1.74
1868	70.3	2.42
1869	70.6	4.85
1870	70.1	4.53
1871	71.2	1.42
1872	71.2	4.18
1873	69.5	0.80
1874	69.4	1.28
1875	65.5	1.47
1876	71.6	1.28
1877	68.5	6.57
1878	70.2	1.85
1879	70.0	1.61
1880	68.6	6.02
1881	72.7	1.63
1882	69.5	5.72
1883	64.9	0.18
1884	66.9	1.30
1885	63.6	6.75
1886	69.3	4.69
6887	68.0	0.89
1888	67.6	1.87
1889	68.6	0.68
1890	65.4	3.60
1891	67.9	4.82
1892	68.3	5.12
1893	68.1	0.56
1894	68.8	0.00
1895	71.2	4.64
1896	70.0	4.73
1897	65.9	1.69
1898	69.0	2.73
1899	71.4	0.70
1900	73.3	2.98
1901	68.4	2.49
1902	64.2	0.68
1903	64.3	6.73
1904	65.9	3.26
1905	69.6	3.92
1906	73.5	4.35
1907	65.5	2.87
1908	68.4	3.99
1909	71.0	1.61
1910	68.2	1.76
1911	68.2	1.48
1912	65.7	2.19
1913	69.4	5.60
1914	68.9	3.33
1915	63.4	4.63
1916	71.0	1.58
1917	67.0	1.47
1918	72.2	1.44

BAROMETER—Mean, 30.00 inches; highest, 30.37 inches, on 19th; lowest, 29.70 inches on 4th.

TEMPERATURE—Highest, 102°, on 6th; lowest, 45°, on 3rd; greatest daily range, 35°, on 41st; least daily range, 12°, on 16th; normal for month, 68.4°; excess or deficiency this month, +3.8°; accumulated excess or deficiency since January 1st, −220° average daily, same period, −0.9°; highest in 33 years 102°, lowest, 32°.

PRECIPITATION (in inches)—Total amount, 1.44; normal, 2.63; excess or deficiency this month, −1.19; since Jan. 1st., −2.71; greatest amount in any 24 hour period, 0.42, on 28th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southwest; total movement, 3,312 miles; average hourly velocity, 4.5 miles; maximum velocity 22, from the southwest, on the 11th.

DATES OF—Auroras, 2, 24, 31; fog, dense, 0; hail, 0; thunderstorms, 4, 8, 11, 21, 23, 28, 31; Halos: solar, 1, 26, 30; lunar, 0 Frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., September, 1918.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	79	48	64	0	Clear	100
2	76	58	67	T.	Cloudy	9
3	76	54	65	0	Partly cloudy	45
4	58	52	55	1.42	Cloudy	0
5	67	46	56	0	Partly cloudy	75
6	70	39	54	0	Partly cloudy	68
7	72	48	60	0.25	Partly cloudy	60
8	75	45	60	0	Clear	94
9	78	52	65	0	Cloudy	41
10	63	41	52	0	Clear	88
11	61	44	52	0.39	Cloudy	0
12	63	48	56	0.26	Cloudy	15
13	66	46	56	0	Partly cloudy	43
14	74	42	58	0.04	Partly cloudy	62
15	70	50	60	0.10	Cloudy	10
16	56	43	50	0.18	Cloudy	0
17	64	41	52	0	Partly cloudy	78
18	61	42	52	0.03	Cloudy	15
19	53	39	46	0.01	Cloudy	16
20	54	38	46	0.02	Cloudy	10
21	55	37	46	T.	Cloudy	56
22	60	34	47	0	Partly cloudy	48
23	69	42	56	0	Partly cloudy	37
24	62	51	56	0.05	Cloudy	21
25	65	42	54	0.12	Partly cloudy	56
26	54	34	44	0	Partly cloudy	87
27	66	34	50	0	Clear	100
28	72	40	56	0	Clear	89
29	58	34	46	0.01	Cloudy	36
30	54	35	44	0	Partly cloudy	75
31	....	....	....	....	....	....

Mean highest temperature	65.0
Mean lowest temperature	43.3
Mean temperature for month	54.2
Total precipitation for month	2.88

WEATHER.

number days clear	5
Partly cloudy	12
Cloudy	13
With 0.01 or more of precipitation	13

SUNSHINE.

Number hours sunshine	178.4
Possible hours sunshine	374.8
Percentage of possible	48

This month since 1863. WF

Year.	Mean temperature.	Total precipitation.
1863	....	0.89
1864	59.6	3.53
1865	67.7	4.79
1866	55.8	5.80
1867	56.6	1.42
1868	58.8	2.95
1869	63.5	1.43
1870	63.7	2.85
1871	59.1	0.79
1872	62.0	5.21
1873	67.4	3.50
1874	62.8	1.27
1875	58.5	2.89
1876	56.3	3.65
1877	61.3	1.38
1878	63.2	3.41
1897	56.2	3.19
1880	55.8	3.10
1881	69.7	2.91
1882	59.9	0.67
1883	56.4	2.34
1884	65.1	3.34
1885	58.9	3.75
1886	62.1	5.40
1987	58.9	4.72
1888	57.8	1.89
1889	61.2	0.79
1890	57.7	1.67
1891	65.1	1.10
1892	60.8	2.17
1893	58.4	1.84
1894	63.7	2.59
1895	66.6	0.85
1896	57.6	6.73
1897	62.9	0.80
1898	63.3	3.00
1899	57.0	2.14
1900	63.2	0.89
1901	61.7	1.67
1902	58.7	5.88
1903	61.0	2.86
1904	62.0	2.35
1905	63.8	3.21
1906	67.5	0.76
1907	61.8	4.68
1908	66.4	0.65
1909	60.4	1.51
1910	60.2	2.74
1911	61.5	5.05
1912	62.7	3.33
1913	61.0	1.53
1914	60.3	2.65
1915	63.2	6.55
1916	60.4	2.17
1917	58.6	4.60
1918	54.2	2.88

BAROMETER—Mean, 30.07 inches; highest, 30.52 inches, on 10th; lowest, 29.62 inches, on 18th.

TEMPERATURE—Highest, 79°, on 1st; lowest, 34°, on 27th; greatest daily range, 32 on 27th; least daily range, 6° on 4th; normal for month, 61.6°; excess or deficiency this month. —7.4°. accumulated excess or deficeiney since January 1st, —443°; average daily, same period, —2.6°; highest in 33 years, 99°, lowest, 21°.

PRECIPITATION (in inches)—Total amount, 2.88; normal, 2.62 excess or deficiency this month, ±0.26; since January 1st, —2.45; greatest amount in any 24 hour period, 1.42, on 4th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southwest; total movement, 3,478 miles; average hourly velocity, 4.8 miles. maximum velo ity 18, from the southwest, on the 18th.

DATES of—Auroras, 0; fog, dense, 0; hail, 12; thunderstorms, 7, 12, 18; Halos: solar, 2, 17; lunar, 17; frost: killing, 0 heavy, 22, 26, 27, 29; light, 6, 17.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., October, 1918.

Date.	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.	This month since 1863.		
	Highest.	Lowest.	Mean.				Year.	Mean temperature.	Total precipitation.
							1863	....	1.04
1	60	29	44	0.10	Cloudy	83	1864	45.7	1.86
2	64	44	54	0.04	Partly cloudy	48	1865	46.5	2.76
3	61	38	50	0	Clear	100	1866	49.5	3.57
4	72	34	53	0	Cloudy	78	1867	50.6	2.11
5	75	60	68	0.01	Partly cloudy	59	1868	45.2	1.11
6	60	44	52	T.	Cloudy	0	1869	40.8	1.72
7	61	40	50	0	Partly cloudy	70	1870	52.5	2.29
8	66	31	48	0.05	Partly Cloudy	73	1871	53.9	1.4'
9	71	47	59	0.15	Clear	82	1872	47.4	0.67
10	73	47	60	0	Partly Cloudy	99	1873	44.7	1.91
11	76	51	64	0.06	Partly cloudy	78	1874	49.1	0.49
12	73	57	65	0.01	Partly cloudy	86	1875	42.9	5.81
13	65	40	52	0	Partly cloudy	54	1876	43.7	1.26
14	60	35	48	0	Clear	96	1877	50.8	5.69
15	69	35	52	0	Partly cloudy	61	1878	48.3	1.99
16	66	43	54	0	Clear	100	1879	57.3	1.57
17	77	46	62	0	C.ear	90	1880	46.2	2.84
18	56	37	46	0	Clear	100	1881	52.5	5.56
19	61	31	46	0.35	Partly cloudy	95	1882	52.7	2.64
20	65	40	52	0.33	Partly cloudy	60	1883	46.2	3.66
21	59	34	46	0	Clear	100	1884	50.9	5.73
22	60	37	48	0	Cloudy	76	1885	45.0	3.08
23	56	42	49	0.44	Cloudy	0	1886	52.4	0.95
24	61	50	56	0.69	Cloudy	0	1887	45.0	1.86
25	59	48	54	0.04	Cloudy	0	1888	45.7	3.00
26	55	44	50	T.	Cloudy	0	1889	44.2	0.65
27	68	53	60	0.84	Cloudy	5	1890	49.1	4.56
28	59	45	52	T.	Cloudy	18	1891	48.8	0.82
29	61	43	52	T.	Partly cloudy	69	1892	48.3	0.78
30	54	38	46	0	Partly cloudy	91	1893	49.7	3.61
31	43	32	38	0.10	Cloudy	0	1894	49.8	1.91
							1895	45.0	1.41
							1896	44.6	1.03
							1897	53.1	2.15
Mean highest temperature						63.4	1898	49.6	3.55
Mean lowest temperature						41-8	1899	53.2	2.68
Mean temperature for month						52.6	1900	56.6	2.77
Total precipitation for month						3.21	1901	49.6	4.61
							1902	49.6	1.53
							1903	51.0	2.01
WEATHER.							1904	48.6	1.90
							1905	50.9	1.75
							1906	49.2	2.36
Number days clear						7	1907	46.0	2.22
Partly cloudy						13	1908	51.5	0.82
Cloudy						11	1909	46.2	0.71
With 0.01 or more precipitation						14	1910	51.8	2.27
							1911	48.0	5.00
							1912	50.4	3.44
SUNSHINE.							1913	50.2	3.30
							1914	54.6	2.81
							1915	51.1	0.70
Number hours sunshine						208.4	1916	49.7	2.53
Possible hours sunshine						341.9	1917	41.2	3.44
Percentage of possible						61	1918	52.6	3.21

BAROMETER—Mean, 30.06 inches; highest, 30.44 inches, on 1st; lowest, 29.52 inches, on 28th.

TEMPERATURE.—Highest, 77°, on 17th; lowest, 29°, on 1st; greatest daily range, 38°, on 4th; least daily range, 11°, on 31st; normal for month, 49.0°; excess or deficiency this month, ±3.6°; accumulated excess or deficiency since January 1st, —333°; average daily, same period, —1.1°; highest in 33 years, 90°; lowest, 10°.

PRECIPITATION (in inches)—Total amount, 3.21; normal, 2.23 excess or deficiency this month, ±0.98; since January 1st, —1.47; greatest amount in any 24 hour period, 0.84, on 27th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southwest; total movement, 4,714 miles; average hourly velocity, 6.3 miles; maximum velocity 6.3 miles; maximum velocity 22, from the northeast, on 18th.

Dates of—Auroras, 0; fog, dense, 8; hail, 0; thunderstorms, 0; Halos: solar, 1-4, 10, 19, 22, 30; lunar, 15; frost: killing, 1; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., November, 1918.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	39	33	36	T.	Cloudy	1
2	49	29	39	0	Clear	100
3	54	40	47	0.16	Cloudy	9
4	49	36	42	0	Cloudy	8
5	54	36	45	0	Clear	100
6	61	36	48	T.	Clear	98
7	60	48	54	0.11	Cloudy	8
8	54	48	51	1.34	Cloudy	0
9	53	38	46	0.02	Cloudy	20
10	46	29	38	0	Partly cloudy	49
11	48	27	38	0	Partly cloudy	70
12	50	31	40	0	Partly cloudy	51
13	46	31	38	0	Partly cloudy	63
14	53	28	40	0	Clear	100
15	57	43	50	0	Cloudy	10
16	53	49	51	0.25	Cloudy	0
17	63	50	56	0.63	Cloudy	21
18	51	38	44	0.13	Cloudy	0
19	43	35	39	0.27	Cloudy	0
20	40	34	37	0.04	Cloudy	0
21	38	34	36	0	Cloudy	0
22	34	28	31	T.	Cloudy	0
23	37	27	32	0	Clear	74
24	39	24	32	0	Clear	100
25	38	24	31	0	Partly cloudy	53
26	38	20	29	0	Partly cloudy	78
27	44	25	34	0	Clear	100
28	49	31	40	0.24	Cloudy	2
29	43	29	36	T.	Partly cloudy	35
30	35	21	28	0.03	Cloudy	41
31	....	....	....	....	....	....

Mean highest temperature	47.3
Mean lowest temperature	33.4
Mean temperature for month	40.4
Total precipitation for month	3.22

WEATHER.

Number days clear	7
Partly cloudy	7
Cloudy	16
With 0.01 or more precipitation	11

SUNSHINE.

Number hours sunshine	116.0
Possible hours sunshine	292.1
Percentage of possible	40

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	0.40
1864	37.9	4.12
1865	38.6	0.68
1866	37.9	2.60
1867	40.4	1.77
1868	36.8	2.44
1869	32.1	1.93
1870	38.4	0.91
1871	32.0	1.25
1872	29.8	0.98
1873	28.5	2.03
1874	35.0	1.61
1875	33.0	1.11
1876	36.3	0.91
1877	38.2	3.67
1878	36.3	2.16
1979	38.2	4.55
1880	27.5	2.32
1881	38.2	4.09
1882	36.3	1.83
1883	38.1	3.98
1884	34.1	1.84
1885	37.2	2.90
1886	33.9	1.48
1887	35.7	2.28
1888	38.5	3.12
1889	37.4	2.67
1890	39.1	2.30
1891	34.0	3.34
1892	34.2	1.84
1893	35.6	2.19
1894	32.5	0.97
1895	35.4	3.87
1896	37.1	1.05
1897	36.5	2.94
1898	33.1	2.72
1899	39.7	1.72
1900	35.3	5.10
1901	32.8	1.21
1902	43.0	2.46
1903	34.0	1.45
1904	40.0	0.04
1905	35.8	2.25
1906	37.0	2.66
1907	36.0	1.83
1908	38.2	1.82
1909	44.5	3.74
1910	34.0	1.37
1911	33.8	3.40
1912	38.6	2.86
1913	41.7	2.38
1914	37.6	1.40
1915	39.8	2.23
1916	38.0	1.68
1917	35.8	0.82
1918	40.04	3.22

BAROMETER—Mean, 30.01 inches; Highest, 30.50 inches, on 11th; Lowest, 29.12 inches, on 28th.

TEMPERATURE—Highest, 63°, on 17th; lowest, 20°, on 26th; greatest daily range, 25°, on 14th: least daily range, 4° on 16th normal for month, 36.8°; excess or deficiency this month, +3.6°; accumulated excess or deficiency since January 1st, −249°; average daily, same period, −0.7°; highest in 33 years, 72°, lowest, 0.

PRECIPITATION (in inches)—Total amount, 3.22; normal, 2.41; excess or deficiency this month, +0.81; since January 1st, −0.66. greatest amount in any 24 hour period, 1.36, on 7th and 8th; total snowfall, 0.3 inches.

WIND—Prevailing direction, southwest; total movement, 5,366 miles; average hourly velocity, 7.5 miles; maximum velocity 36, *from the southwest, on 28th.*

DATES of—Auroras, 0; fog dense, 0; hail, 0; sleet, 0; thunderstorms, 17; Halos, solar, 12; lunar, 0 frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist

Monthly Meteorological Summary, Lansing, Mich., December, 1918.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	35	14	24	T.	Cloudy	0
2	38	29	34	0.01	Cloudy	0
3	36	27	32	0.14	Cloudy	0
4	30	28	29	0.02	Cloudy	0
5	38	27	32	0	Cloudy	0
6	36	29	32	0	Cloudy	70
7	48	31	40	0	Clear	63
8	53	32	42	0	Clear	73
9	42	31	36	0.41	Cloudy	4
10	35	30	32	0.34	Cloudy	0
11	44	32	38	0.01	Partly cloudy	42
12	42	29	36	0.02	Cloudy	71
13	45	36	40	0.55	Cloudy	0
14	41	36	38	0.14	Cloudy	0
15	42	30	36	0	Partly cloudy	52
16	46	29	38	0	Clear	100
17	42	28	35	0	Partly cloudy	68
18	32	27	30	0	Cloudy	0
19	50	29	40	0	Clear	78
20	47	36	42	0.02	Cloudy	0
21	50	44	47	0.97	Cloudy	0
22	54	40	47	0.02	Cloudy	21
23	40	28	34	0	Cloudy	13
24	30	28	29	0.74	Cloudy	0
25	28	9	18	0.11	Clear	78
26	29	16	22	0	Cloudy	16
27	29	13	21	T.	Cloudy	30
28	25	2	14	T.	Partly cloudy	71
29	23	19	21	0.01	Cloudy	0
30	34	22	28	0	Cloudy	29
31	36	30	33	0.10	Cloudy	0

Mean highest temperature 38.7
Mean lowest temperature 27.1
Mean temperature for month 32.9
Total precipitation for month 3.61

WEATHER.

Number days clear 5
Partly cloudy 4
Cloudy 22
With 0.01 or more of precipitation 16

SUNSHINE.

Number hours sunshine 79.4
Possible hours sunshine 280.8
Percentage of possible 28

This month since 1863. Year.	Mean temperature.	Total precipitation.
1863	....	1.71
1864	24.4	3.20
1865	26.7	1.43
1866	25.5	1.90
1867	25.3	1.34
1868	21.2	1.35
1869	28.2	2.11
1870	24.8	2.57
1871	21.1	1.76
1872	15.7	1.06
1873	29.5	3.02
1874	27.0	0.37
1875	31.6	2.80
1876	15.2	1.29
1877	36.6	1.03
1878	21.3	2.27
1879	27.5	3.55
1880	22.1	0.85
1881	34.3	1.75
1882	24.8	0.88
1883	26.4	1.28
1884	34.7	4.15
1885	27.8	2.14
1886	19.7	1.56
1887	27.3	3.32
1888	30.4	1.20
1889	36.8	2.61
1890	26.4	1.12
1891	34.6	1.47
1892	25.6	1.52
1893	27.6	2.28
1894	30.1	0.93
1895	28.5	5.39
1896	28.1	0.80
1897	25.6	2.02
1898	24.8	1.42
1899	25.0	1.51
1900	26.7	0.50
1901	21.6	3.00
1902	24.8	2.89
1903	19.7	1.75
1904	21.7	1.42
1905	30.2	2.54
1906	26.8	1.85
1907	22.7	4.19
1908	26.4	2.08
1909	23.0	2.91
1910	21.6	1.28
1911	31.1	1.58
1912	31.0	1.20
1913	31.8	0.55
1914	21.6	1.57
1915	24.8	1.01
1916	22.7	2.11
1917	19.1	0.74
1918	32.9	3.61

BAROMETER—Mean, 30.05 inches; highest, 30.62 inches, on 18th; lowest, 29.48 inches, on 3rd.

TEMPERATURE—Highest, 54°, on 22nd; lowest, 2°, on 28th; greatest daily range, 23°, on 28th; least daily range, 2°, on 24th; *normal for month, 26.8°; excess or deficiency this month, +6.1°; accumulated excess or deficiency since January, 1st, −39*; average daily, same period, −0.1°; highest in 33 years, 62°, lowest, −24°.

PRECIPITATION (in inches)—Total amount, 3.61; normal, 2.08; excess or deficiency this month, +1.53; since January 1st, +0.87; greatest amount in any 24 hour period, 0.97, on 21st and 22nd; total snowfall, 10.0 inches.

WIND—Prevailing direction, southwest; total movement, 4,875 miles; average hourly velocity, 6.6 miles; maximim velocity 25, from the northwest on the 5th.

DATES OF—Auroras, 7, 8; fog, dense, 31; hail, 0; sleet, 12, 13; thunderstorms, 0; Halos: solar, 7, 12, 17; lunar, 0; frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., January, 1919.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	35	20	28	0.06	Cloudy	0
2	20	9	14	0.01	Cloudy	0
3	9	−2	4	0	Clear	100
4	13	−1	6	T.	Partly cloudy	90
5	19	−1	9	T.	Cloudy	14
6	28	18	23	0.03	Cloudy	17
7	33	27	30	0.01	Cloudy	4
8	29	21	25	0.01	Cloudy	0
9	31	10	20	0.02	Clear	92
10	33	13	23	0	Clear	96
11	25	10	18	0	Clear	88
12	33	10	22	0	Cloudy	47
13	40	31	36	0	Cloudy	42
14	34	28	31	T.	Cloudy	0
15	38	27	32	0	Partly cloudy	64
16	41	31	36	0	Partly cloudy	88
17	43	31	37	0	Partly cloudy	66
18	42	31	36	0.02	Partly cloudy	48
19	32	29	30	0	Cloudy	0
20	35	29	32	0	Cloudy	14
21	52	35	44	0	Partly cloudy	67
22	44	36	40	0.02	Cloudy	23
23	44	33	38	0.17	Cloudy	0
24	41	30	36	0	Partly cloudy	70
25	46	30	38	T.	Partly cloudy	66
26	44	29	36	0	Clear	100
27	48	28	38	0	Partly cloudy	82
28	36	25	30	0.01	Cloudy	0
29	32	25	28	T.	Cloudy	3
30	41	28	34	0	Clear	100
31	34	20	27	0	Clear	100

Mean highest temperature	34.7
Mean lowest temperature	22.3
Mean temperature for month	28.5
Total precipitation for month	0.36

WEATHER.

Number days clear	7
Partly cloudy	9
Cloudy	15
With 0.01 or more of precipitation	10

SUNSHINE.

Number hours sunshine	140.7
Possible hours sunshine	292.5
Percentage of possible	48

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	.....	.....
1864	22.3	0.94
1865	21.1	0.65
1866	21.2	2.03
1867	17.6	1.68
1868	19.0	1.47
1869	29.5	0.87
1870	25.4	1.93
1871	24.8	3.95
1872	21.6	0.42
1873	15.9	2.98
1874	27.7	3.53
1875	12.9	1.81
1876	30.2	1.63
1877	18.1	1.33
1878	29.1	1.12
1879	19.2	0.49
1880	37.1	2.67
1881	17.0	2.27
1882	24.9	1.47
1883	14.4	1.53
1884	15.5	1.23
1885	15.3	2.70
1886	18.8	2.66
1887	18.2	3.25
1888	15.4	2.18
1889	28.0	1.53
1890	31.5	2.81
1891	26.7	0.82
1892	19.2	0.96
1893	14.8	1.78
1894	26.9	1.37
1895	17.5	1.04
1896	24.6	0.79
1897	22.3	4.17
1898	24.9	3.07
1899	21.7	2.03
1900	25.6	1.17
1901	22.2	1.51
1902	20.5	0.43
1903	20.7	1.20
1904	14.4	2.82
1905	18.2	1.07
1906	31.8	1.99
1907	23.2	3.97
1908	23.8	1.89
1909	26.6	2.16
1910	23.4	2.52
1911	25.2	1.43
1912	9.2	0.80
1913	26.2	3.10
1914	27.0	2.98
1915	20.4	1.54
1916	27.6	3.11
1917	21.0	1.55
1918	10.2	2.08
1919	28.5	0.36

BAROMETER—Mean 30.04 inches; highest, 30.57 inches, on 11th; lowest, 29.54 inches, on 1st.

TEMPERATURE—Highest, 52°, on 21st; lowest, −2°, on 3rd; greatest daily range, 23°, on 12th; least daily range, 3° on 19th; normal for month, 22.7°; excess or deficiency this month, +5.8°; accumulated excess or deficiency since January 1st, +180°. average daily, same period, +5.8°; highest in 34 years, 63°; lowest, −26°.

PRECIPITATION (in inches)—Total amount, 0.36; normal, 2.09; excess or deficiency this month, −1.73; since January 1st, −1.73; greatest amount in any 24 hour period, 0.19 on 22nd and 23rd; total snowfall, 1.3 in.

WIND—Prevailing direction, southwest; total movement, 5,867 miles; average hourly velocity 7.9 miles; maximum velocity 26, from the west, on the 10th.

DATES OF—Auroras, 0; fog, dense, 20, 22; hail, 0; sleet, 18; thunderstorms, 0; Halos: solar, 12, 16, 21; lunar, 12; frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., February, 1919.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	32	17	24	0	Partly cloudy	89
2	35	16	26	0	Partly cloudy	85
3	44	28	36	0.06	Cloudy	23
4	42	19	30	T.	Cloudy	1
5	26	15	20	T.	Partly cloudy	77
6	30	14	22	0	Clear	100
7	31	12	22	0	Clear	100
8	28	14	21	T.	Cloudy	33
9	30	13	22	T.	Partly cloudy	95
10	31	6	18	0	Partly cloudy	100
11	33	25	29	0.02	Cloudy	4
12	35	28	32	0	Cloudy	0
13	39	32	36	0.39	Cloudy	0
14	39	33	36	0.12	Cloudy	1
15	33	22	28	0.03	Cloudy	32
16	30	24	27	T.	Cloudy	39
17	32	25	28	0.04	Cloudy	0
18	34	20	27	0	Partly cloudy	100
19	33	13	23	0	Clear	100
20	34	20	27	0.04	Cloudy	47
21	37	30	34	0.01	Cloudy	0
22	38	32	35	0.33	Cloudy	0
23	37	30	34	T.	Cloudy	3
24	41	26	34	0	Cloudy	78
25	37	14	26	0.09	Cloudy	1
26	18	9	14	T.	Cloudy	74
27	25	11	18	0.01	Cloudy	37
28	45	17	31	0.36	Cloudy	7
29						
30						
31						

Mean highest temperature	33.9
Mean lowest temperature	20.2
Mean temperature for month	27.0
Total precipitation for month	1.50

WEATHER.

Number days clear	3
Partly cloudy	6
Cloudy	19
With 0.01 or more of precipitation	12

SUNSHINE.

Number hours sunshine	128.1
Possible hours sunshine	295.2
Percentage of possible	43

BAROMETER.

Mean, 29.97 inches.
Highest, 30.67 inches, on 19th.
Lowest, 29.20 inches, on 14th.

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863		
1864	27.3	0.27
1865	27.6	1.76
1866	22.7	2.28
1867	30.9	3.23
1868	18.7	1.28
1869	26.7	2.95
1870	24.2	1.20
1871	25.6	1.73
1872	21.3	0.46
1873	19.1	0.77
1874	25.5	1.55
1875	8.0	2.20
1876	27.4	3.04
1876	32.3	0.00
1878	28.1	2.74
1879	20.4	1.43
1880	29.2	1.62
1881	21.6	3.77
1882	35.1	2.28
1883	19.8	4.50
1884	23.4	3.69
1885	8.9	0.73
1886	22.3	1.35
1887	24.3	5.71
1888	22.0	1.70
1889	18.3	1.17
1890	31.5	1.79
1891	26.7	2.20
1892	27.3	1.93
1893	21.3	1.83
1894	21.2	0.53
1895	16.4	0.12
1896	24.3	1.51
1897	26.4	0.67
1898	23.8	1.82
1899	16.8	1.51
1900	17.4	3.44
1901	12.8	1.83
1902	18.6	0.44
1903	20.6	1.58
1904	12.0	3.30
1905	15.8	1.25
1906	23.6	1.12
1907	19.2	0.25
1908	21.6	3.19
1909	28.4	2.36
1910	21.9	2.65
1911	27.6	1.77
1912	15.8	2.04
1913	20.0	1.65
1914	12.7	0.79
1915	29.4	2.10
1916	19.2	0.69
1917	15.5	0.62
1918	21.8	3.04
1919	27.0	1.50

BAROMETER—Mean, 29.97; inches; highest, 30.67 inches, on 19th; lowest, 29.20 inches, on 14th.

TEMPERATURE—Highest, 45°, on 28th; lowest, 6°, on 10th; greatest daily range, 28°, on 28th; least daily range, 6°, on 14th; normal for month, 21.6°; excess or deficiency this month, +5.1°; accumulated excess or deficiency since January 1st, +344°; average daily, same period, +5.8°; highest in 34 years, 62°, lowest, −25°.

PRECIPITATION (in inches)—Total amount, 1.50; normal, 2.02; excess or deficiency this month, −0.52; since January 1st, −2.25. Greatest amount in any 24 hour period, 0.43 on 13th and 14th. Total snowfall, 2.1 in.

WIND—Prevailing direction, west; total movement, 5,207 miles; average hourly velocity, 7.7 miles; maximum velocity 34, from the southwest, on 28th.

DATES OF—Auroras, 0; hail, 28; sleet, 25; thunderstorms, 12, 22; Halos: solar, 2, 7, 19, 20, 24; lunar, 0; Frost: killing, 0; heavy 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., March, 1919.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	23	17	20	T.	Cloudy	57
2	36	21	28	0	Cloudy	51
3	49	23	36	0	Partly cloudy	100
4	48	22	35	0.40	Cloudy	6
5	27	14	20	0.03	Cloudy	69
6	25	9	17	T.	Partly cloudy	70
7	33	13	23	0	Partly cloudy	78
8	35	19	27	0.30	Partly cloudy	51
9	35	24	30	1.11	Cloudy	41
10	36	20	28	0.01	Cloudy	23
11	38	24	31	0	Clear	100
12	46	23	34	0	Clear	100
13	37	23	30	T.	Cloudy	2
14	33	20	26	0	Cloudy	56
15	49	33	41	0.56	Cloudy	0
16	66	49	58	0.23	Cloudy	31
17	56	32	44	0.39	Cloudy	0
18	43	29	36	0	Partly cloudy	61
19	54	28	41	0	Clear	100
20	62	31	46	0	Clear	100
21	40	25	32	0	Partly cloudy	33
22	43	23	33	0	Clear	100
23	53	23	38	0	Clear	100
24	54	31	42	0	Partly cloudy	87
25	63	35	49	0	Partly cloudy	82
26	58	33	46	0.08	Cloudy	0
27	37	24	30	0	Cloudy	53
28	40	21	30	0	Clear	100
29	44	26	35	0.19	Clear	86
30	34	26	30	0.18	Cloudy	31
31	37	20	28	0	Clear	98

Mean highest temperature	43.0
Mean lowest temperature	24.5
Mean temperature for month	33.8
Total precipitation for month	3.48
WEATHER.	
Number days clear	9
Partly cloudy	8
Cloudy	14
With 0.01 or more of precipitation	11
SUNSHINE.	
Number hours sunshine	223.8
Possible hours sunshine	370.5
Percentage of possible	60

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	37.1	2.26
1865	37.0	2.79
1866	[illegible]	3.39
1867	29.7	0.68
1868	37.8	4.65
1869	27.6	1.65
1870	30.3	3.01
1871	38.2	3.91
1872	24.8	2.04
1873	28.3	1.73
1874	32.3	1.79
1875	26.2	1.02
1876	30.6	4.84
1877	24.5	5.60
1878	40.9	3.12
1879	33.2	1.57
1880	35.5	1.70
1881	30.3	2.66
1882	36.0	3.58
1883	24.9	0.71
1884	29.9	3.67
1885	21.3	0.58
1886	31.3	2.63
1887	28.3	1.78
1888	27.0	1.88
1889	37.6	1.22
1890	28.2	1.54
1891	29.3	2.41
1892	29.9	1.31
1893	28.2	2.82
1894	40.1	1.25
1895	27.2	0.27
1896	28.7	1.31
1897	33.0	2.08
1898	37.0	3.59
1899	26.3	3.30
1900	23.6	1.88
1901	31.1	2.94
1902	38.6	3.16
1903	41.0	1.25
1904	30.2	3.45
1905	35.4	3.15
1906	26.2	1.86
1907	38.6	2.84
1908	34.8	2.19
1909	29.9	0.90
1910	44.0	0.40
1911	32.7	1.21
1912	22.4	1.92
1913	31.0	3.76
1914	31.1	1.52
1915	30.1	0.78
1916	26.2	3.09
1917	34.6	2.88
1918	37.1	3.58
1919	33.8	3.48

BAROMETER—Mean, 30.19 inches; highest, 30.69 inches, on 22nd; lowest, 29.55 inches, on 9th.

TEMPERATURE—66°, on 16th; lowest, 9°, on 16th; greatest daily range, 31°, on 20th; least daily range, 6° on 1st; normal for month, 32.3°; excess or deficiency this month, +1.5°; accumulated excess or deficiency since January 1st, +376°; average daily, same period, +4.2°; highest in 34 years, 82°; lowest, −12°.

PRECIPITATION (in inches)—Total amount, 3.48; normal, 2.26; excess or deficiency this month, +1.22-since January 1st, −1.03; greatest amount in any 24 hour period, 1.41, on 8th and 9th; total snowfall, 22.2 inches.

WIND—Prevailing direction, southwest; total movement, 5,838 miles; average hourly velocity, 7.8 miles. Maximum velocity 24, from the southwest, on 17th.

DATES OF—Auroras, 19, 20; Hail, 0; sleet, 4, 15; thunderstorms, 0; Halos, solar, 2, 3, 6, 7, 8, 9, 16, 23; lunar, 12, 13; Frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., April, 1919.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	35	17	26	0	Clear	100
2	49	23	36	0	Partly cloudy	100
3	45	35	40	0.16	Cloudy	0
4	51	41	46	0	Cloudy	13
5	61	40	50	T.	Cloudy	49
6	73	48	60	0.09	Clear	91
7	61	44	52	0.70	Cloudy	35
8	73	45	59	0.03	Cloudy	65
9	66	45	56	0.26	Cloudy	32
10	66	42	54	0.28	Cloudy	10
11	43	41	42	T.	Cloudy	0
12	44	37	40	0.01	Cloudy	0
13	57	36	46	0	Partly cloudy	82
14	53	38	46	0.02	Cloudy	11
15	38	32	35	1.17	Cloudy	0
16	43	35	39	0.77	Cloudy	4
17	45	36	40	0.04	Cloudy	7
18	56	32	44	0	Clear	100
19	64	35	50	0	Cloudy	88
20	66	40	53	0.04	Partly cloudy	68
21	62	32	47	0	Clear	10
22	67	37	52	0	Partly cloudy	57
23	57	37	47	0.34	Cloudy	22
24	40	25	32	T.	Partly cloudy	52
25	43	24	34	T.	Clear	94
26	57	29	43	0	Clear	100
27	55	27	41	0.11	Cloudy	44
28	54	38	46	0.11	Cloudy	15
29	54	32	43	0	Partly cloudy	82
30	55	35	45	T.	Cloudy	16
31	.....	.....	.....	.....	.....	.....

Mean highest temperature	54.4
Mean lowest temperature	35.3
Mean temperature for month	44.8
Total precipitation for month	4.13

WEATHER.

Number days clear	6
Partly cloudy	6
Cloudy	18
With 0.01 or more of precipitation	15

SUNSHINE.

Number hours sunshine	192.7
Possible hours sunshine	402.5
Percentage of possible	48

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	.....	.....
1864	45.9	3.80
1865	47.4	2.32
1866	48.9	1.40
1867	48.2	2.19
1868	43.7	1.83
1869	45.7	3.42
1870	50.4	2.02
1871	49.8	2.97
1872	47.4	1.26
1873	43.2	3.88
1874	36.9	1.67
1875	41.1	0.61
1876	44.2	2.08
1877	46.2	4.14
1878	50.6	3.76
1879	44.8	1.25
1880	45.9	7.06
1881	45.6	1.73
1882	44.7	1.88
1883	43.5	1.90
1884	43.7	1.95
1885	43.6	2.47
1886	50.2	1.99
1887	45.4	0.90
1888	44.0	1.15
1889	46.6	2.02
1890	47.2	3.20
1891	47.4	1.74
1892	44.5	2.04
1893	43.5	4.81
1894	48.4	2.76
1895	48.6	0.67
1896	52.6	2.77
1897	44.6	2.74
1898	43.6	2.12
1899	49.8	1.23
1900	47.4	2.00
1901	46.4	2.16
1902	44.6	1.70
1903	43.0	4.40
1904	39.4	0.50
1905	44.6	1.49
1906	46.6	2.43
1907	37.8	2.81
1908	44.6	2.15
1909	42.8	5.96
1910	49.2	2.48
1911	44.3	2.11
1912	45.6	3.12
1913	45.9	3.10
1914	44.7	2.90
1915	51.6	1.00
1916	45.7	1.91
1917	42.4	5.59
1918	42.4	1.97
1919	44.8	4.13

BAROMETER—Mean, 30.01 inches; highest, 30.41 inches, on 21st; lowest, 29.42 inches, on 10th.

TEMPERATURE—Highest, 73°, on 8th; lowest, 17°, on 1st; geatestr daily range, 30°, on 21st; least daily range, 2°, on 11th; normal for month, 45.6°; excess or deficiency this month, —0.8°; accumulated excess or deficiency since January 1st, +351°; average daily, same period, +2.9°; highest in 34 years, 88 ; lowest, 10°.

PRECIPITATION (in inches)—Total amount, 4.13; normal, 2.54; excess or deficiency this month, +1.59; since January 1st, +0.56; greatest amount in any 24 hour period, 1.24, on 15th and 16th; total snowfall, 3.2 inches.

WIND—Prevailing direction, southwest; total movement, 5,524 miles; average hourly velocity, 7.7 miles; maximum velocity 25, from the south, on 10th.

DATES OF—Auroras, 0; sleet, 17; thunderstorms, 6, 7, 9, 10; Halos: solar, 2, 19, 22, 23; lunar, 8, 18; frost: killing, 15, 18, 21, 24, 25, 26, 27, 29; *heavy*, 19; *light*, 30.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., May, 1919.

Date.	Temperature. Highest.	Lowest.	Mean.	Precipitation in inches.	Character of day.	Percentage of possible.
1	53	36	44	0.85	Cloudy	0
2	55	38	46	0	Partly cloudy	62
3	43	35	39	1.46	Cloudy	0
4	66	42	54	0.95	Cloudy	17
5	52	40	46	0	Cloudy	40
6	66	37	52	0	Partly cloudy	99
7	62	44	53	T.	Clear	82
8	47	40	44	0.15	Cloudy	6
9	58	36	47	0	Cloudy	68
10	51	41	46	T.	Cloudy	7
11	56	38	47	T.	Cloudy	42
12	61	36	48	0	Partly cloudy	83
13	70	38	54	0	Clear	100
14	73	42	58	0.09	Partly cloudy	75
15	68	48	58	0.33	Partly cloudy	69
16	68	49	58	0.09	Cloudy	64
17	62	42	52	T.	Partly cloudy	40
18	67	40	54	0	Clear	100
19	69	40	54	T.	Cloudy	62
20	48	44	46	0.12	Cloudy	0
21	53	44	48	0.01	Cloudy	0
22	63	39	51	0.19	Cloudy	64
23	63	44	54	0.05	Cloudy	34
24	71	44	58	0	Partly cloudy	95
25	77	46	62	0	Partly cloudy	100
26	82	48	65	0	Clear	100
27	86	52	69	0	Clear	100
28	81	48	64	0	Clear	100
29	87	52	70	0	Clear	100
30	89	55	72	0	Clear	100
31	93	61	77	0	Clear	100

Mean highest temperature	65.8
Mean lowest temperature	43.2
Mean temperature for month	54.5
Total precipitation for month	4.29

WEATHER.

Number days clear	9
Partly cloudy	8
Cloudy	14
With 0.01 or more of precipitation	11

SUNSHINE.

Number hours sunshine	281.9
Possible hours sunshine	454.7
Percentage of possible	62

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	.....	.....
1864	60.2	2.87
1865	57.6	1.77
1866	55.0	3.48
1867	61.1	3.80
1868	59.1	2.80
1869	56.0	2.05
1870	64.3	1.16
1871	61.4	1.97
1872	58.5	3.72
1873	56.9	3.05
1874	59.6	1.77
1875	60.8	4.46
1876	58.0	4.13
1877	58.2	2.23
1878	54.6	3.44
1879	58.8	2.45
1880	64.3	5.59
1881	65.2	2.11
1882	52.7	4.04
1883	52.8	5.66
1884	56.9	3.95
1885	55.8	2.30
1886	58.1	2.67
1887	64.3	2.42
1888	53.7	3.66
1889	57.4	3.61
1890	53.7	4.98
1891	55.7	1.63
1892	54.5	5.92
1893	54.4	2.86
1894	56.9	4.83
1895	61.8	2.06
1896	66.5	3.14
1897	55.8	3.29
1898	56.5	2.15
1899	58.8	3.59
1900	58.8	4.17
1901	55.2	2.42
1902	58.4	4.92
1903	59.5	2.63
1904	57.4	2.40
1905	56.7	5.17
1906	56.6	3.05
1907	51.2	2.22
1908	59.6	5.59
1909	55.8	2.44
1910	51.5	4.13
1911	63.5	2.67
1912	57.6	6.57
1913	56.2	2.22
1914	58.6	4.66
1915	51.5	2.74
1916	56.6	5.13
1917	50.2	3.37
1918	61.1	2.89
1919	54.5	4.29

BAROMETER—Mean, 29.94 inches; highest, 30.33 inches, on 5th; lowest, 29.40 inches, on 1st.

TEMPERATURE—Highest, 93°, on 31st; lowest, 35°, on 3rd; greatest daily range, 35°, on 29th; least daily range, 4°, on 20; normal for month, 57.1°; excess or deficiency this month, −2.6°; *accumulated excess or deficiency since January 1st*, +272°; average, daily, same period, +1.8 ; highest in 34 years, 95 ; lowest, 17 .

PRECIPITATION (in inches)—Total amount, 4.29; normal, 3.58; excess or deficiency this month, +0.71; since January 1st, +1.27-greatest amount in any 24 hour period, 1.85, on 3rd, and 4th; total snowfall, 0.0 inches.

WIND—Prevailing direction, northeast; total movement, 4,432 miles; average hourly velocity, 6.0 miles; Maximum velocity 20, from the southwest on 1st.

DATES of—Auroras, 2; fog, dense, 4, 22; hail, 0; thunderstorms, 4; Halos: solar, 6, 7, 9, 14, 13, 22; lunar, 0; frost: killing, 0; heavy 0; light, 12, 13.

DEWEY A. SEELEY,
Meteorologist.

Monthly Meteorological Summary, Lansing, Mich., June, 1919.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.	This month since 1863 Year.	Mean temperature.	Total precipitation.
1	93	62	78	0	Clear	100	1863	....	....
2	93	67	80	0	Clear	88	1864	67.6	3.88
3	89	68	78	0	Clear	88	1865	70.8	3.55
4	88	67	78	0	Partly cloudy	81	1866	66.6	5.37
5	84	62	73	T.	Partly cloudy	78	1867	71.6	2.83
							1868	68.5	3.55
6	76	58	67	0.06	Partly cloudy	68	1869	64.4	4.40
7	75	55	65	0.27	Cloudy	51	1870	70.9	7.27
8	74	53	64	0	Pa-tly cloudy	88	1871	68.2	2.93
9	80	52	66	0	Partly cloudy	95	1872	71.8	3.45
10	86	57	72	0	Parity cloudy	78	1873	70.6	2.96
							1874	70.6	5.07
11	88	65	76	0.21	Cloudy	37	1875	66.6	1.84
12	89	64	76	0.01	Partly cloudy	52	1876	68.1	4.34
13	91	67	79	0	Clear	90	1877	65.9	3.53
14	90	66	78	0	Clear	100	1878	64.1	3.15
15	90	66	78	T.	Partly cloudy	75	1879	66.0	2.87
16	89	67	78	0.22	Partly cloudy	65	1880	67.6	5.04
17	89	64	76	0	Partly cloudy	71	1881	64.3	4.37
18	90	53	76	0	Clear	100	1882	66.5	5.57
19	85	66	76	0.81	Partly cloudy	36	1883	65.9	11.35
20	85	66	76	0.05	Partly cloudy	74	1884	68.9	2.83
							1885	64.7	6.01
21	85	55	70	0	Partly cloudy	73	1886	65.7	1.92
22	78	51	64	0	Partly cloudy	83	1887	68.5	2.47
23	82	59	70	0	Partly cloudy	97	1888	67.9	2.51
24	84	60	72	1.04	Cloudy	50	1889	62.8	3.42
25	79	66	72	0.46	Cloudy	12	1890	70.3	3.92
							1891	67.4	2.55
26	82	66	74	0.05	Cloudy	37	1892	67.7	4.33
27	67	47	57	T.	Cloudy	25	1893	66.6	4.85
28	70	46	58	0	Clear	100	1894	71.4	1.30
29	77	44	60	0	Clear	100	1895	71.4	1.01
30	85	51	68	0	Clear	100	1896	69.9	2.60
31	....	....	....	....	....	....	1897	64.2	2.57
							1898	67.6	4.91
							1899	68.2	1.15
							1900	65.2	2.57
Mean highest temperature						83.8	1901	68.0	3.57
Mean lowest temperature						60.0	1902	61.8	7.28
Mean temperature for month						71.9	1903	62.0	6.28
Total precipitation for month						3.18	1904	65.6	2.49
							1905	66.2	7.47
							1906	67.1	4.61
WEATHER.							1907	65.0	2.37
							1908	70.0	1.23
Number days clear						9	1909	66.7	2.86
Partly cloudy						15	1910	64.9	1.95
Cloudy						6	1911	68.0	3.77
With 0.01 or more of precipitation						10	1912	63.1	0.97
							1913	67.8	1.01
							1914	66.6	4.11
SUNSHINE							1915	61.0	3.96
							1916	61.4	5.39
Number hours sunshine						335.9	1917	62.4	4.54
Possible hours sunshine						459.4	1918	64.4	2.07
Percentage of possible						73	1919	71.9	3.18

BAROMETER—Mean, 30.07 inches; highest, 30.33 inches, on 12th lowest, 29.72 inches, on 25th.

TEMPERATURE—Highest, 93°, on 1st; lowest, 44°, on 29th; greatest daily range, 34° on 30th, least daily range, 13° on 25th; normal for month 67.2 ; excess or deficiency this month, +4.6°; accumulated excess or deficiency since Jan. 1st, +412°; average daily, same period, +2.3°; highest in 34 years 99°, lowest, 34°.

PRECIPITATION (in inches)—Total amount, 3.18; normal, 3.40; excess or deficiency this month, −0.22; since January 1st, +1.05; greatest amount in any 24 hour period, 1.49, on 24th and 25th; total snowfall, 0.0 inches.

WIND—Prevailing direction, southeast; total movement, total movement, 2,886 miles; average hourly velocity, 4.0 miles; maximum velocity 25, from the southwest on 19th.

DATES OF—Auroras, 0; fog dense, 0; hail, 0; thunderstorms, 7, 11, 12, 15, 16, 17, 19, 20, 24; Halos: solar, 22, 27; lunar, 0; frost: heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

REPORT OF THE DIVISION OF EXTENSION WORK.

President F. S. Kedzie.

Dear Sir—During the year the greatest effort has been continued to improve the extension organization for carrying the service of the College, the Experiment Station, and the U. S. Department of Agriculture to those who cannot come to the College. The Extension Service recognizes its great responsibility and duty in attempting to secure the adoption into common practice of the practical and useful information made available by these institutions through years of investigation and research. To carry on this service the organization has five closely related groups; viz.,

1. Department of Specialists.
2. County Agricultural Agents.
3. Home Economics Workers.
4. Boys' and Girls' Club Workers.
5. Market Agents.

Within each county having an agricultural agent, farm bureaus have been developed through which the above five groups of workers can reach each town and community of the county.

In brief, the County Farm Bureau consists of a central directing body known as an executive committee. Each member of this committee is designated as the county leader of some one of the agricultural problems chosen for attention during the year and for which he is qualified to act as leader. A committee of one or more farmers is appointed for each of the active communities, each committeeman being chosen as leader of some proposed line of work. Each executive committeeman, together with the community committeeman assigned to the same problem constitute the county project committee. This body outlines the program of the bureau in that special line and carries it forward to completion.

It has been encouraging during the year to observe that this form of organization has accomplished results on problems needing the combined effort of all farmers within the county. Among such problems may be mentioned the control of grasshoppers, the elimination of scrub sires, the dissemination of improved grains, the control of plant diseases and the formation of marketing organizations.

The Smith-Lever Act approved May, 1914, not only provides funds for the work, but stipulates that it shall be cooperative with the Department of Agriculture. This Act defines cooperative extension work in Section II.

> "That cooperative agricultural extension work shall consist of the giving of instruction and practical demonstrations in agriculture and home economics to persons not attending or resident in said colleges in the several communities, and imparting to such persons information on said subjects through field demonstrations, publications and otherwise; and this work shall be carried on in such manner as may be mutually agreed upon by the Secretary of Agriculture and the state agricultural college or colleges receiving the benefits of this act."

The projects approved by the Secretary of Agriculture are listed below and are reported upon by the leader of each as appended hereto.

TITLES OF EXTENSION PROJECTS.

1. Administration.
2. County Agents.
3. Home Economics.
4. Extension Schools.
5. Boys' & Girls' Clubs.
6. Farm Crops.
7. Live Stock.
8. Horticulture.
9. Potatoes and Vegetables.
10. Muck Crops
11. Farm Management Demonstrations.
12. Insect Control & Apiculture.
13. Drainage Engineering.
14. Forestry.
15. Dairy Products.
16. Marketing (Fed. Cooperative).
17. Poultry.
18. Home Demonstration Agents.

EXTENSION BULLETINS PUBLISHED DURING THE FISCAL YEAR.

Bulletin Number.	Title.	Author.	Pages.
Extension Bulletin No. 4 (revised)	The Home Vegetable Garden	C. W. Waid	27
Extension Bulletin No. 13 (revised)	Oat Smut and Its Control	G. H. Coons	4
Extension Bulletin No. 16	The Joint Worm in Michigan	R. H. Pettit	4
Extension Bulletin No. 17	The Stinking Smut of Wheat	G. H. Coons	4
Extension Bulletin No. 18	Good Health		42
Extension Bulletin No. 19	Grasshopper Control	Don B. Whelan	2
Extension Bulletin No. 20	Hotbeds and Coldframes	C. W. Waid	8
Club Bulletin No. 12	Hot School Lunch Project	Home Economics Department	32
Club Bulletin No. 13	Boys' and Girls' Clubs	R. A. Turner	35
Extension Course Notes No. 17	Breads for War Time	Home Economics	4
Extension Course Notes No. 18	How Can I Use Less Sugar	Home Economics	4
Extension Course Notes No. 19	Suggestions on preservation of Meat	Home Economics	4
Extension Course Notes No. 20	Clothing for Children	Home Economics	4
Extension Course Notes No. 21	The Care of Clothing	Home Economics	4
Extension Course Notes No. 22	How to Know Materials	Home Economics	4
Extension Course Notes No. 23	How to buy Clothing	Home Economics	4
Extension Course Notes No. 24	Home Dressmaking Patterns	Home Economics	4
Extension Course Notes No. 25	Remodeling	Home Economics	2
Extension Course Notes No. 26	Layettes	Home Economics	2
Extension Course Notes No. 27	Jellies, Jams, Marmalades, Conserves, Fruit Butters and Sweet Pickles	Home Economics	4
Extension Course Notes No. 28	Home Canning Guide	Home Economics	2

APPOINTMENTS DURING THE YEAR.

O. T. Goodwin	Specialist, Dairy Products	Aug. 15, '18
Aurelia B. Potts	Asst. Home Dem. Agent Leader	Sept. 9, '18
Alice M. Kuenzli	Home Dem. Agent, Manistee	Sept. 15, '18
Ray A. Turner	State Leader, Boys' & Girls' Clubs	Oct. 1, '18
Nina Streeter	Home Dem. Agent, Saginaw	Oct. 1, '18
W. B. Sutherland	Asst. Farm Mgt. Demonstrator	Oct. 21, '18
Osee Hughes	Home Dem. Agent, Detroit	Nov. 1, '18
I. T. Pickford	Specialist in Horticulture	Dec. 6, '18
H. G. Clothier	County Agent, Calhoun	Nov. 15, '18
A. G. Kettunen	Asst. Boys' & Girls' Clubs	Dec. 16, '18
Blanche Ingersol	Asst. Dem. Agent, Detroit	Jan. 1, '19
R. V. Tanner	County Agent, Barry	Jan. 11, '19
Carl H. Knopf	County Agent, Manistee	Jan. 16, '19
James L. Kraker	County Agent, Benzie	Jan. 21, '19
Geo. C. Raviler	Field Agent in Market Organization	Feb. 1, '19
E. K. Chamberlain	Specialist, Farm Crops	Feb. 15, '19
E. G. Amos	County Agent, Menominee	Feb. 21, '19
C. O. T. Scheetz	County Agent, Alpena	Mar. 1, '19

Margaret Hutty	Asst. Boys' & Girls' Clubs	Mar.	1, '19
E. B. More	County Agent, Calhoun	Mar.	16, '19
Eva Carrett	Home Dem. Agent, Cass	Apr.	16, '19
H. E. Dennison	County Agent, Shiawassee	Apr.	16, '19
Paul C. Jamieson	County Agent, Calhoun	Apr.	16, '19
C. W. Wing	County Agent, Charlevoix	Apr.	16, '19
Howard Hindes	County Agent, Montmorency	Apr.	23, '19
Arthur C. Lytle	County Agent, Otsego	May	1, '19
Wm. A. Anderson	Asst. State Leader	June	10, '19

County Club Leaders were appointed on Emergency funds of one to six months during the year in the following counties: Saginaw, Houghton, Barry, Branch, Calhoun, Charlevoix, Cheboygan, Clinton, Eaton, Genessee, Gogebic, Ingham, Iron, Jackson, Marquette, Mecosta, Missukee, Ontonagon, Kalamazoo, Kent, Lenawee, Hillsdale, Osceola, Baraga, Washtenaw, Alpena, Berrien, Bay, Chippewa, Delta, Emmet, Gratiot Ionia, Isabella, Menominee, Muskegon, Oakland, Ottawa.

TRANSFERS.

Helen Arms	Saginaw Home Dem. Agent to Asst. Leader, Home Economics	Oct.	1, '18
Frank Sandhammer	County Agent, Manistee to Asst. County Agent Leader	Jan.	21, '19
R. G. Carr	County Agent, Ontonagon to Kent	Jan.	16, '19
Robert A. Wiley	County Agent, Leelanau to Grand Traverse	Feb.	16, '19
Coral Havens	Asst. Home Economics to Asst. in Milk Campaign, B. A. I.	Apr.	16, '19
B. O. Hagerman	Asst. Co. Agent, Ottawa, to County Club Leader, Gogebic	May	31, '19

RESIGNATIONS.

Margaret Justin	Asst. Home Economics, U. P.	Aug.	31, '18
*F. L. True	County Agent, Alpena	Sept.	9, '18
E. C. Lindeman	State Leader, Boys' & Girls' Club	Sept.	30, '18
C. A. Spaulding	Asst. Leader, Boys' & Girls' Club	Sept.	30, '18
Earl Bangs	Asst. County Agt., Van Buren	Oct.	1, '18
W. T. Bandeen	County Agent, Midland	Oct.	10, '18
R. N. Kebler	Asst. Boys' & Girls' Clubs	Oct.	31, '18
Jessie M. DeBoth	Asst. Boys' & Girls' Clubs	Oct.	31, '18
Don A. Meeker	County Agent, Shiawassee	Nov.	6, '18
Vera Gruner	Asst. Home Economics	Nov.	1, '18
Earl P. Robinson	Asst. County Agt. Leader	Dec.	31, '18
H. G. Smith	County Agent, Kent	Dec.	31, '18
R. G. Brumm	County Agent, Barry	Jan.	1, '19
L. R. Queal	County Agent, Montmorency	Jan.	1, '19
Effie M. Carp	Home Dem. Agent, Gogebic	Jan.	1, '19
Clinton F. Smith	County Agent, Charlevoix	Feb.	15, '19
M. E. Duckles	County Agent, Grand Traverse	Feb.	15, '19
H. B. Clothier	County Agent, Calhoun	Feb.	15, '19

E. B. Hill	County Agent, Menominee	Feb.	21, '19
Esther Keating	Home Dem. Agent, Marquette	Mar.	31, '19
Earl R. Trangmar	Supervisor of Publications	Apr.	1, '19
E. B. More	County Agent, Calhoun	Apr.	1, '19
D. L. McMillan	Specialist, Sheep Husbandry	Apr.	1, '19
James N. McBride	State Market Director	Apr.	1, '19
Don B. Whelan	Specialist, Insect Control	May	31, '19
Verne Freeman	Specialist, Sheep Husbandry	June	30, '19

* Military service.

Very truly yours,
R. J. BALDWIN,
Extension Director.

East Lansing, Mich., June 30, 1919.

REPORT OF EXTENSION WORK IN HOME ECONOMICS.

BY MAY PERSON.

There have been few changes in the personnel of this force during the past year. Four specialists have been employed during the entire year. During the time when the demand for help in food conservation was very heavy it was necessary to have additional help, as it was again during the extension schools.

PLANS AND ORGANIZATION.

1. Plans.
   The Home Economics Specialists have had two distinct purposes in view:
   a. To be of service along technical lines to the State Leader and her assistants and to the Home Demonstration Agents.
   b. To carry to the women of Michigan living in counties which do not have Home Demonstration Agents, instruction and help in all matters pertaining to the home.
2. Organization.
   a. In counties having Home Demonstration Agents the work has been done under the direction of the State Leader of the Home Demonstration Agents.
   b. In counties having County Agricultural Agents but no Home Demonstration Agents, the work has been done, in so far as possible, through the County Agricultural Agent and his organization. When requests came from other organizations, such as women's clubs or other societies, we have made it an opportunity to bring the organization in touch with the County Agricultural Agent and the Farm Bureau.
   c. In counties having neither a County Agricultural Agent or a Home Demontration Agent, we have worked through the various existing organizations.

Among the organizations with which we have worked during the year are the State Food Administration, the Woman's Committee,

Council of National Defence, Women's clubs, the public schools, the farmers' clubs, the Grange, the State Board of Health, the Red Cross (Central Division, state organization and local chapters), and various church organizations.

FOOD CONSERVATION AND PRESERVATION.

During the first three months of the fiscal year the work of this department consisted almost entirely of war emergency work: that is, the use of wheat and sugar substitutes, and the preservation of fruits and vegetables. Much of this work was done in cooperation with the food Administration.

One method which this department used during the summer to try and meet the demand for help along the line of the use of wheat and sugar substitutes was to hold training classes for volunteer demonstrators. Fourteen such classes were held in fourteen different counties; their was an attendance of 538 women. These women in turn gave demonstrations on the use of substitutes and on cold-pack canning to 2,144 other women.

COUNTY FAIRS.

It has not been the custom of the Home Economics Extension Department during previous years to take an active part in the county fairs. Usually a county fair is not very fertile soil for educational work in this line.

This year, however, because of the unusual food situation, we, together with the State Food and Drug Department, cooperated with the Food Administration in carrying out Food Conservation work at the county fairs.

This department drew up suggestive plans for a Food Conservation Exhibit. These were sent out by the Food Administration to all food Administrators, food conservation chairmen, county agricultural agents, home demonstration agents, and directors of fairs.

All requests which came to the Food Administration for demonstrators were referred to us. We took care of as many as possible and helped the Food Administration find volunteer workers for the others. Specialists from this office assisted a local committee or took charge of the food conservation work at fifteen county fairs. (This does not include fairs in counties where there are home demonstration agents.) The work consisted of helping put up the exhibit, giving demonstrations in canning and the use of substitutes of conditions were favorable, giving short talks, judging, etc.

The type of work which we felt accomplished the most was to stay in the Conservation booth and answer the questions of the women who would stop for a few minutes and explain their particular difficulties. Hundreds of women who could not have been reached in any other way were helped in the use of substitute foods or went away with a more cooperative feeling toward the Food Administration.

PROJECTS OF SPECIALISTS.

Miss Parker has emphasized this year the need of looking after the health of the community—sanitation, clean milk, etc., and the care and

feeding of children of pre-school age. The startling prevalence of malnutrition among children emphasized the need of the work. Both men and women have been interested in her talk on "Community Health". The child welfare work, a large proportion of which has been carried on in cooperation with the home demonstration agents, has been carried on by holding child welfare days, at which time talks and exhibits were given on the care of children, proper feeding and proper clothing, importance of care of the teeth, etc.

The work in clothing has been very popular. There has been much interest in talks and demonstrations on textiles, dyeing, use of patterns, cutting and fitting, use of sewing machine attachments, etc.

After the armistice was signed and the necessity for the use of substitutes was over, the interest in foods gave precedence for a few months to interest in clothing and health. The war has, however, created a real interest in foods among the women of this country, and the prevalence of under nourishment among children emphasizes still further the need of knowledge of nutrition.

In April this department entered into a cooperative project with the Bureau of Animal Industry, Dairy Division, to increase the consumption of milk. A milk campaign was put on in Detroit. Talks on the importance of milk for children were given before 60,000 children and 3,000 adults. As a result of this campaign the consumption of milk during the following three weeks increased 10%.

It has not been possible to do much along the lines of Home Management as a separate project. A household account book was published because the demand for one was so great. Of the 1,000 published, 412 are in actual use by women who have promised to keep the accounts for a year. This project is being carried on by the home demonstration agents. At the end of the year the women keeping accounts will hold community meetings, at which time discussion will be held on home budgets, the value of the living received from the farm, etc.

The Home Economics Extension Schools have presented work along the lines of health, clothing and foods. Due to the influenza, many schools had to be cancelled, so the number given was one less than last year.

Home Economics Extension Work has been given in 66 counties of the state through Extension Schools, single demonstrations and lectures, training schools for leaders, conferences, exhibits, fairs and special campaigns. The number of people reached in this way is as follows:

Extension Schools	37	1825
Canning demonstrations	78	3071
Food talks	28	5211
Food substitutes	92	4568
Health talks and demonstrations	39	2100
Clothing talks and demonstrations	45	2603
Volunteer training classes	14	538
General Home Economics talks	41	3485
	374	23401

Milk campaign	70,000
Fairs	10,000

The Specialists have assisted at five conferences this year. Two of these were for Home Demonstration Agents, two were for the housewives of the state, and one for the Home Economics teachers of Michigan.

The enthusiastic and earnest support which the women of Michigan have recently given the Home Demonstration Agent work augurs well for the new year. There is no longer a question as to whether or not women consider the work helpful and worth while. They have demonstrated their belief and confidence in the work and in the Extension Department of this College.

REPORT ON WORK OF HOME DEMONSTRATION AGENTS.

BY E. V. SMITH.

July 1, 1918, Michigan had home demonstration agents in 19 counties and 3 cities. Later two more counties and one more city were given agents. Of this number all four cities and twelve of the counties were in the lower peninsula, and eight counties were in the upper peninsula. With two exceptions the money for the support of the agents in the county has been appropriated by the Board of Supervisors, $500, being the approximate money appropriated.

Three have also had cars provided for their use; the others travel by rail, either steam or electric, hired auto, or with the county agricultural agents where meetings can be planned together.

Until the signing of the armistice all work naturally assumed the form of emergency work, principally conservation and preservation of foods, clothing, health, time and strength. At the same time the educational principles were always stressed. Since November 11, it has been tending toward a more permanent basis and we believe has become a real definite and essential part of the Farm Bureau work.

The following projects have been carried on by the various agents and will be continued in the counties where Home Demonstration work goes on: Organization, Foods, Clothing, Health, Child Welfare, Home Management, Poultry, and Club Work.

ORGANIZATION.

The home demonstration agents have organized their work in nearly all of the counties under the Farm Bureau plan in cooperation with the county agricultural agent.

The women may become members of the Farm Bureau on an equal basis with the men. Each county executive committee has at least one woman representing the home economics work and each community a woman representative for each project taken up.

In counties where there is no definite Farm Bureau, the agents have a representative woman in each community to act as a leader and who will assist in planning meetings, advertising, and preparing for demonstrations, etc.

FOODS.

Substitutes. During the war wheat, meat, sugar and fat conservation was emphasized by means of lectures, demonstrations, extension schools and food study clubs; also by food shows, although

not as extensively in the counties as we felt it was not a legitimate way of showing food conservation except where the counties contained larger cities and more people could be reached.

Dietetics. One of the greatest outgrowths of the recent war as far as the home is concerned has been to give the housewife, also other members of the family, a greater insight into the needs of food study and proper feeding of the family. Women in the different communities are asking for definite food study and lessons in planning meals. In nearly every case the Home Nursing classes have been or will be followed by Dietetics classes, which shows something of the interest in food principles.

Preservation. The preservation of foods for winter use was taken up very extensively last year by the home demonstration agents. The various methods were discussed and demonstrations given in drying, brining, and canning of fruits, vegetables and meats. In some counties canning centers were established. In others several women clubbed together, bought a canner and worked together, and in this way made the canning work easier. This year some of the women are buying cans, can rubbers, etc., together at wholesale prices.

Increasing Use of Milk. No work can be done along the lines of nutrition without emphasizing the use of milk. The city agents have been especially interested in this, and have all been active, both by educational work among mothers and by helping establish milk stations to increase the consumption of milk and teach people the importance and economy of using it in larger quantities.

Clothing. The interest among women in the clothing work which the agents have offered has been surprising. Doubtless the increased price of all clothing materials and the necessity of utilizing everything on hand, has stimulated interest along this line. Constant demands have come in for talks and demonstrations on cutting and fitting, use of patterns, making over garments, more efficient use of sewing machine attachments, etc.

Health. During the influenza epidemic nearly all of the agents gave their services in one way or another. In several places diet kitchens were established in which the agent had entire supervision of the preparation of foods for the emergency hospitals and homes where entire families were ill. Some helped in establishing the emergency hospitals and acted as nurses. One of the agents in the upper peninsula went into a foreign district and stayed for eight weeks, working almost incessantly.

Home Nursing Classes. Through a cooperative project with the Red Cross the agents have organized from six to twelve home nursing classes in nearly every county. Due to the influenza epidemic a greater need for this work has been felt among the women of the rural communities and much interest shown. The classes have been organized and all arrangements made by agents. The classes have been taught by trained nurses.

Child Welfare. In some counties nearly all the Child Welfare work has been handled by the home demonstration agent. In others this has been done in cooperation with the Woman's Committee, Council of National Defense. This spring, each agent has given from two to four days to a special Child Welfare campaign, put on with the assistance of Miss Parker, the Health Specialist. This has consisted of establishing centers where weighing and measuring of babies was conducted. Talks

and demonstrations on the proper care and feeding of the child were given by physicians, nurses and agents. Exhibits of diets, clothing, proper toys, etc., were held in connection with them.

In two counties the agents working in cooperation with the school comissioner and a nurse visited all the schools of the county; the nurse examining the children and the agent talking proper feeding. Special stress has been given to the value of milk as a food for children.

Follow-up work will continue throughout the year by means of talks and working with individuals.

HOME MANAGEMENT.

Home Accounts. It has been planned originally to have each agent place about six account books in their county with the idea of getting housewives interested in this work. However, it has taken no effort on our part. The women are asking for the books rather than our urging them to keep accounts. There are undoubtedly 400 women in the state using our approved account book. The agents have assisted in starting the accounts and explaining the method. It is planned to call the women together in groups at least twice during the year to discuss methods and results and to see at the end of the year if with their assistance some quite definite budgets cannot be worked out for both rural and town women.

POULTRY.

As the greater per cent of the poultry on the farm is taken care of by the women, this has become quite an important project of the Home Demonstration agents. The agents with the specialist have worked out a very satisfactory project or plan. The women in communities where they are interested form poultry clubs, which meet once in two months and take up a definite study, as for instance; the first year club will consider general health of the flock, incubation, and brooding, stock and culling, marketing, canning and use of canned products. Second year club will consider history of breeds, standard study, winter feeding and crate fattening, poultry house conveniences, boning, etc. Monthly record sheets are sent out by the specialists to agents and they in turn furnish them to club members. Up to the present date seventeen poultry clubs have been organized and are doing splendid work.

CLUB WORK.

In counties where there is no club leader, the girls' club work is handled by the Home Demonstration agent. The agents, after determining where it is possible to organize clubs and having selected the local leaders, the State Club Leader is called into the county to assist with the organization. At the same time they know the Home Demonstration agent is there to help them and to do the follow-up work.

GENERAL WORK.

Aside from these regular projects the Home Demónstration agents have been called upon to assist in war campaigns, Americanization, civics, etc. One agent was asked to go into the school districts of her county and teach the women how to vote. Several others were asked to give help in this work.

During the last month, the question of local financial cooperation from the counties, if they wished to keep their Home Demonstration agents, has had to be presented to the many Farm Bureaus and various Boards of Supervisors. The interest which women and men also—have shown in continuing the Home Demonstration work has been most gratifying, and somewhat of a surprise even to those of us who believe most thoroughly in the possibilities of this line of work. The war has given women a new conception of what feeding their families involves, and they are very earnest in their demands for help along this line, and along other phases of home making as well. Although it has been necessary to discontinue the work in some counties, nowhere have the women willingly seen the work stop.

Counties.	Demonstrations.		Talks.		Teaching Volunteer Classes.		Demonstrations by Volunteers.	
	Number.	Attend.	Number.	Attend.	Number.	Attend.	Number.	Attend.
Allegan	24	456	80	2,333	2	20	....	....
Berrien	24	784	89	3,456	....	....	....	....
Cass	6	98	56	2,544	....	....	....	....
Chippewa	30	651	9	171	2	30	1	16
Dickenson	98	2,017	31	643	23	561	2	175
Delta	32	757	26	1,200	13	80	....	....
Gogebic	26	946	21	646	9	262	....	....
Houghton	57	1,276	36	2,122	40	655	35	618
Iron	8	197	40	1,013	....	....	....	....
Kalamazoo	31	1,090	48	1,958	....	....	....	....
Kent	21	455	18	653	....	....	8	160
Manistee	18*	367	54	2,189	....	....	....	....
Marquette	10	115	14	145	....	....	....	....
Mason	22	228	43	2,017	1	9	2	128
Menominee	47	1,094	50	25,04	20	71	6	234
Ottawa	23	764	75	4,058	1	3	2	75
St. Clair	17	232	126	5,577	....	....	....	....
Schoolcraft	19	505	46	1,951	8	55	8	126
St. Joseph	38	1,735	17	475	....	....	....	....
Saginaw	15	384	24	1,254	....	....	....	....
Wayne	39	392	116	3,254	10	113	9	95
	657	15,607	1,019	40,263	129	1,859	73	1,717
Cities.								
Detroit	96	2,224	9	363	....	....	....	....
Flint	17	393	22	1,468	....	....	....	....
Grand Rapids	86	850	29	630	2	22	3	47
Saginaw	34	675	25	1,720	....	....	....	....
Total city and county	890	19,749	1,104	44,414	131	1,881	79	1,867
State Leader and Assistants	....	....	....	....	....	....	136	4,922

	Meetings.	Atten..
Grand Total	2,340	72,833
Exhibits	....	3,700
Fairs	....	100,00
Milk Campaign	....	70,000

(Cooperative: Dairy Division, Bureau of Animal Industry; Home Economics Extension; 11 Home Demonstration Agents).

REPORT OF BOYS' AND GIRLS' CLUB WORK.

BY RAY A. TURNER.

ORGANIZATION.

The progress in organization has been through the channels already in operation in this department. The administration of this organization has been in the hands of the state, county and local club leaders, together with the advisory boards of the several local clubs. Emphasis has been placed upon the formation or organization of local clubs through which the agricultural, educational and social program of the Division of Extension might be carried on.

Cooperating in the promotion of this organization are the many departments of the Division of Extension together with many outside groups. Among the last named might be mentioned: The Michigan Crop Improvement Association, The State Bankers' Association, The Michigan Potato Growers' Association, The Michigan State Fair, The Department of Public Instruction, the Michigan State Federation of Women's Clubs, Boards of Supervisors in the several counties, Boards of Education in the several counties, Upper Peninsula Development Bureau, the Michigan State Teachers' Association, together with a large number of commercial concerns.

LEADERSHIP.

The staff of paid club leaders now consists of the following persons:

R. A. Turner	State Club Leader	East Lansing.
Anna B. Cowles	State Club Leader for Girls	East Lansing.
A. G. Kettunen	Asst. Club Leader	Marquette.
Barbara Van Heulen	Asst. Club Leader for Girls	Marquette.
W. A. Anderson	Asst. State Club Leader	East Lansing.
Elda Robb	Asst. State Club Leader	East Lansing.
Margaret Hutty	Asst. State Club Leader	East Lansing.

COUNTY CLUB LEADERS.

Y. G. T. Rehner	Eben Junction	Alger County.
Traverse Ousterhout	Sterling	Arenac County.
Nathalia Vasold	Hastings, Court House	Barry County.
G. E. Butterfield	Bay City, McKingley School	Bay County.
Viva Osborn	Coldwater	Branch County.
L. D. Sears	Battle Creek	Calhoun County.
Ruth E. Wheaton	Cheboygan	Cheboygan County.
Martin Melican	Escanaba	Delta County.
Kelsey B. Smith	Flint, Court House	Genessee.
C. E. Gunderson	Ironwood	Gogebic County.
E. H. Wilcox	Traverse City	Grand Traverse Co.
A. N. Varney	Litchfield	Hillsdale County.
B. O. Hagerman	Houghton	Houghton County.
G. S. Kies	Lansing, City Hall	Ingham County.
Percy Angove	Ionia	Ionia County.
G. E. Bishop	Alpha	Iron County.
Floyd Ferguson	Mt. Pleasant	Isabella County.
Alberta Hill	Jackson, 510 Lansing Ave.	Jackson County.

Ruth M. Cooley	Kalamazoo, 1408 Bank St.	Kalamazoo County.
Frank A. Davis	Gd. Rapids, Ass'n. of Com. Bd.	Kent County.
Mrs. R. N. Peters	Adrian, 318 Cherry St.	Lenawee County.
R. N. Kebler	Menominee, Agricul. School	Menominee County.
W. J. Atchison	Muskegon	Muskegon County.
C. A. Lewis	Highland Pk. R. F. D., No. 2.	Oakland County.
Evelyn Pepper	LeRoy, R. F. D., No. 1	Osceola County.
Theresa McDonald	Saginaw, W. S., Court House.	Saginaw County.
Ernest F. Lyons	Ann Arbor, Court House	Washtenaw County.
G. O. Stewart	Dearborn	Wayne County.

ASSISTANT COUNTY CLUB LEADERS.

Margaret Hill	Battle Crk., Willard Library.	Calhoun County.
L. Merle Chubb	East Lansing	Ingham County.
Grace M. Watson	Gd. Rapids, Ass'n. of Com. Bd.	Kent County.
Gladys Lahym	Birmingham, R. F. D. No. 3.	Oakland County.
Mrs. Amy B. Huesman	Ann Arbor	Washtenaw County.
Etta Paulson	Grosse Point	Wayne County.
Mrs. Mary H. Grosvenor	Detroit, 213 Pingree Ave.	Wayne County.
Merle Russell,	Highland Park High School,	Wayne.

In addition to these paid leaders, there were 1,413 local volunteer club leaders in the various counties throughout the State. There were 55 County Agricultural Agents and County Home Demonstration Agents who assisted in supervising clubs. In 29 counties the Commissioner of Schools assisted in a similar way. County Y. M. C. A. Secretaries in 8 counties assisted in organizing clubs and discovering local leaders for the same.

PROJECTS.

Clubs have been organized in the following projects:

Summer Projects		Winter Projects.
Crop.	*Stock.*	
Corn.	Pig.	Handicraft.
Bean.	Calf.	Garment Making.
Potato.	Sheep.	School Lunch.
	Poultry.	
Canning.	Rabbit.	
Gardening.		

Some of these such as stock projects, have developed into year around projects.

TRAINING SCHOOL FOR CLUB LEADERS.

State and county training schools have been held for the purpose of developing club leaders. Six state-wide training schools have been conducted at Detroit, Kalamazoo, Grand Rapids, and East Lansing. Ten county training schools have been held in the various counties. In addition to these, a "Course in Club Leadership" was presented in thirty-one of the County Normal Training Classes. One hundred sixty-one sessions were held and two hundred seventy-seven persons received this training.

ACHIEVEMENT DAYS.

Following the completion of a season's work, sixty-one local and county Achievement Days were held. At these times, honors and awards and prizes were given to the club members who finished their project requirements. On February 6 and 7 a State Achievement Day was held at M. A. C. and was attended by two hundred five club members and twenty-three leaders from over the State. At this time, the winners of the State Championships were announced.

STATISTICAL SUMMARY OF RESULTS.

Project of Work.	Clubs organized.	Enrollment.	Members reporting.	Value of products.	Cost of production.	Net profit.
Corn	19	85	56	$3,073.04	$844.72	2,228.32
Potato	86	617	540	12,921.72	4,630.68	8,291.04
Garden	1,448	29,110	17,164	133,546.44	18,514.44	15,032.00
Home Canning	649	13,234	8,010	88,303.00	51,684.27	33,694.73
Mother, Daughter, Canning	22	240	188	10,518.00	6,418.00	4,100.00
Sugar Beet	2	15	10	227.00	169.06	57.94
Poultry	65	520	280	9,690.60	3,566.40	6,124.20
Calf	23	138	88	12,323.00	8,142.12	4,180.88
Pig	22	116	102	5,246.40	2,463.10	2,383.30
Garment	215	2,527	1,063	5,250.15	2,093.94	3,165.21
Handicraft	68	619	229	900.54	291.24	609.30
Bean	40	328	160	6,060.50	1,669.50	4,391.00
Sheep	14	88	50	2,146.50	1,605.00	541.50
Baking	1	7	7	14.35	10.00	4.35
Hot School Lunch	16	344	198	876.69	389.90	486.79
Rabbit	13	98	....	....	....	....
Total	2,700	47,989	28,125	$291,106.93	$103,456.37	$188,290.56

REPORT OF EXTENSION SCHOOLS AND MISCELLANEOUS FARMERS' MEETINGS.

BY KARL H. MCDONEL.

Extension schools were held during the winter months beginning November first and lasting until the first of April. At the beginning of the season, a program had been carefully worked out arranging for approximately one hundred twenty agricultural schools and eighty home economics schools, but the influenza epidemic caused this number to be decreased to fifty-eight agricultural and thirty-seven home economics schools. Cancelling so many of the schools, necessitated a complete revision of the schedule and in many cases, gave very short time to advertise and make local arrangements. However, the average attendance was very high.

The courses given consisted of four lectures on any two of the following subjects:

- Farm Crops.
- Farm Management.
- Animal Husbandry.
- Muck Crops.
- Soils.
- Insect Pests.
- Farm Engineering.
- Poultry.
- Home Economics.
- Horticulture.
- Dairy Husbandry.
- Drainage.
- Marketing.

Besides the regular subjects, talks were also given at mass meetings in interest of war subscriptions, etc.

All arrangements for the meetings were made by the local people together with the County Home Demonstration and Agricultural Agents. Two specialists were present at each school except where local agents took part; then only one person was sent.

The special assistance of H. E. Dennison in Dairying, C. O. T. Scheetz in Farm Crops, and Vera Gruner in Home Economics was secured for the schools. The Soils Department very kindly permitted Mr. Grantham to assist with soils work at the schools. Whenever it was possible for members of the faculty to get away, they were used in the schools.

In some instances, it was impossible to give a two-day meeting so a one-day meeting was held. Here, only one specialist was present from the College. Besides the above mentioned meetings, the Poultry Department put on a series of poultry schools covering from three to six days. These schools were held in cooperation with the County Farm Bureau and the poultry associations of the county.

Free admission to the public was given in all cases except in the largest cities. The expense of operating these schools was met by collecting from breeders, an entry fee for birds to be shown and judged. Lectures were given on breeds, breeding, feeding, poultry house construction, diseases, and demonstrations in killing, dressing, cooking, canning, and culling were also given.

Moving pictures that were loaned by the United States Department were shown every night.

Much of the credit for the success of the schools should be given to Prof. Burgess of the Poultry Department and his assistants.

The following tables summarize the different meetings:

TWO-DAY AGRICULTURAL EXTENSION SCHOOLS.

Place.	County.	Subjects.	Average attendance.	Total attendance.
Alverno	Cheboygan	Dairy	24	97
Munro	Cheboygan	Dairy-Soils	14	53
Millersburg	Presque Isle	Soils	25	98
Stutsmanville	Emmet	Dairy-Soils	12	49
Alanson	Emmet	Dairy-Soils	23	72
Cottreville	St. Clair	Farm Management	23	92
China	St. Clair	Farm Management	32	128
Albion	Calhoun	Farm Management, Animal Husbandry	46	185
Marshall	Calhoun	Farm Management, Animal Husbandry	36	146
Paw Paw	Van Buren	Poultry-Soils	29	115
Auburn	Bay	Dairy-Crops	17	69
Gobbleville	Van Buren	Poultry	21	205
Gilead	Branch	Farm Management Soils	47	189
Zeeland	Ottawa	Dairy	92	367
Holland	Ottawa	Horticulture	50	200
Three Oaks	Berrien	Farm Management, Crops, Animal Husbandry	17	66
M. E. College	Berrien	Farm Management, Crops, Animal Husbandry	87	175
Colon	St. Joseph	Farm Management, Animal Husbandry	50	200
Ganges	Allegan	Dairy-Poultry	38	152
New Richmond	Allegan	Dairy-Poultry	27	110
Durand	Shiawassee	Dairy-Soils	45	180
Chesaning	Saginaw	Farm Management, Soils	37	149
North Branch	Lapeer	Dairy-Crops	32	96
Burnside	Lapeer	Farm Management, Dairy Crops,	83	250
Ensley	Newaygo	Poultry, M. Crops	41	123
Ashland	Newaygo	Poultry, M. Crops	85	341
Cressey	Barry	Poultry, Dairy	34	170
Woodland	Barry	Poultry, Dairy	49	155
Garfield	Newaygo	Crops, Farm Mechanics	57	228
Brookside	Newaygo	Crops, Farm Mechanics	57	229
Hinchman	Berrien	Soils	44	177
Beaverton	Gladwin	Animal Husbandry, Poultry	72	216
Gladwin	Gladwin	Animal Husbandry, Poultry	35	140
Harrietta	Wexford	Animal Husbandry, Soils	30	120
Mesick	Wexford	Animal Husbandry, Soils	30	119
St. Joseph	Berrien	Horticulture, Crops	11	20
Buchanan	Berrien	Crops	56	85
Ypsilanti	Washtenaw	Dairy, Farm Management, Educational	112	560
Ash Center	Monroe	Farm Management, Insects	61	185
Petersburg	Monroe	Farm Management, Insects	71	286
Yale	St. Clair	Poultry	75	300
Birchville	St. Clair	Poultry	31	95
Diamondale	Eaton	Soils, Animal Husbandry, Farm Management	75	300
Eaton Rapids	Eaton	Farm Management, Dairy	10	42
Hudson	Lenawee	Crops, Poultry	125	175
Lakeview	Montcalm	Crops, Dairy	56	225
Greenville	Montcalm	Crops, Dairy	34	103
Big Rapids	Mecosta	Animal Husbandry, Soils, Farm Management	6	17
Rapid City	Kalkaska	Dairy, Potatoes and Vegetables	62	125
Kalkaska	Kalkaska	Dairy, Potatoes and Vegetables	21	85
Alba	Antrim	Dairy, Crops	31	125
Millburg	Berrien	Soils, Horticulture	134	535
Lapeer	Lapeer	Dairy	6	21
Boyne City	Charlevoix	Soils, Dairy	16	67
Ironton	Charlevoix	Soils, Dairy	14	44
Clay Banks	Oceana	Dairy	28	113
Rothbury	Oceana	Dairy	36	145
Saginaw Town	Saginaw	Dairy	17	69

TWO-DAY HOME ECONOMICS SCHOOLS.

Place.	County.	Subjects.	Average attendance.	Total attendance.
Kalkaska	Kalkaska	Foods, Health	56	169
Rapid City	Kalkaska	Foods, Textiles	29	68
Barker Creek	Kalkaska	Foods, Textiles	106	213
Ashland	Newaygo	Foods, Textiles	40	162
Burnside	Lapeer	Foods, Textiles	110	330
Chesaning	Saginaw	Foods, Health	27	106
Ensley	Newaygo	Foods, Textiles	21	65
North Branch	Lapeer	Foods, Textile, Poultry	26	[illegible]
New Richmond	*Allegan*	*Foods, Textiles, Health*	14	56
Ganges	Allegan	Foods, Textiles, Health	25	100
Holland	Ottawa	Foods	2	5
Zeeland	Ottawa	Foods	35	35
Lake View	Montcalm	Foods, Textiles, Poultry	56	180
Petersburg	Monroe	Foods, Textiles, Poultry	32	129
Ash Center	Monroe	Foods, Textiles	17	35
Greenville	Montcalm	Foods, Textiles, Poultry	12	36
Ypsilanti	Washtenaw	Foods, Textiles, Health, Poultry	62	250
Gladwin	Gladwin	Foods, Textiles	39	158
Mesick	Wexford	Foods, Textiles, Poultry	25	100
Rothbury	Oceana	Foods, Textiles, Health	20	82
Dale	*Gladwin*	*Foods, Textiles*	33	135
Harrietta	Wexford	Foods, Textiles	26	78
Woodland	Barry	Foods, Textiles	35	105
Cranston	Oceana	Foods, Textiles, Health	20	20
Cressey	Barry	Foods, Textiles	30	90
Auburn	Bay	Foods, Textiles	16	48
Gilead	Branch	Foods, Textiles	73	293
Stutsmanville	Emmet	Foods, Textiles, Health	13	53
Munro	Cheboygan	Foods, Textiles, Health	16	65
Alverno	Cheboygan	Foods, Textiles, Health	22	88
Alanson	Emmet	Foods, Textiles, Health	16	65
Ironton	Charlevoix	Foods, Textiles	17	51
Boyne City	*Charlevoix*	*Foods, Textiles*	7	28
Marshall	Calhoun	Foods, Textiles	10	160
Devereaux	Jackson	Foods, Textiles, Health	38	150
Plymouth	Wayne	Foods, Textiles, Poultry	26	105
St. Joseph	Berrien	Foods, Textiles, Health	50	200

ONE-DAY FARMERS' MEETINGS.

Place.	County.	Subjects.	Average attendance.	Total attendance.
Three Rivers	St. Joseph	Dairy	21	26
Sturgis	St. Joseph	Dairy	43	55
Trenton	Wayne	Dairy	45	55
Warren	Wayne	Potatoes and Vegetables	45	55
Dearborn	Wayne	Potatoes and Vegetables	60	60
Mahopac	Oakland	Potatoes and Vegetables	100	125
Waterford	Oakland	Potatoes and Vegetables	100	100
Camp Custer	Calhoun	Soils	500	1,000
Henderson	Shiawassee	Farm Management	100	100
Romeo	Macomb	Animal Diseases	50	60
Davis	Macomb	Animal Diseases	45	55
Camp Custer	Calhoun	Farm Crops	295	590
South Haven	Van Buren	Soil Bacteria	100	100
Wayne	Wayne	Horticulture	25	25
Northville	Wayne	Horticulture	15	30
Constantine	St. Joseph	Forestry	65	65
New Hudson	Oakland	Farm Mechanics	100	300
Milford	Oakland	Farm Mechanics	60	120
Ortonville	Oakland	Farm Mechanics	125	250
Marion	Osceola	Live Stock, Soils	100	200
	Osceola	Live Stock, Soils	100	200
Le Roy	Osceola	Live Stock, Soils	112	225
Reed City	Osceola	Live Stock, Soils	45	90
Fennville	Allegan	Horticulture	250	325
Farmington	Oakland	Horticulture	55	75
Deerfield	Livingston	Horticulture	100	100
Hastings	Barry	Forestry	15	15
Waterford	Oakland	Farm Crops	40	40
Romeo	Macomb	Horticulture	30	50
Dayton	Newaygo	Horticulture	60	60
Jackson	Jackson	Poultry	65	65
Adrian	Lenawee	Dairy	25	25
Dundee	Monroe	Dairy	100	100
Fowlerville	Livingston	Soils, Horticulture	75	75
Sunfield	Eaton	Rural Sanitation	100	100
Charlotte	Eaton	Rural Sanitation	35	70
St. Joseph	Berrien	Plant Diseases	300	300
Lake City	Missaukee	Crops, Dairy, Potatoes and Vegetables	150	150
Coloma	Berrien	Poultry	42	65
Harbert	Berrien	Poultry	45	58
Eaton Rapids	Eaton	Poultry	150	150
Cohoctah	Livingston	Poultry	160	160
Chesterfield	Macomb	Poultry	24	28
Richmond	Macomb	Poultry	125	150
Delta	Eaton	Poultry	37	37
Mason	Ingham	Poultry	109	109
Saugatuck	Ottawa	Horticulture	105	105
Highland	Livingston	Soils, Potatoes and Vegetables	48	96
Carson City	Montcalm	Crops, Drainage	50	50
Warren	Macomb	Drainage	25	25
New Haven	Macomb	Drainage	20	40
Albic	Saginaw	Dairy	22	45
Wacausta	Clinton	Farm Management	75	150
Riggsville	Cheboygan	Farm Management	24	92
Tower	Cheboygan	Farm Management	35	35
Grant	Cheboygan	Farm Management	22	22
Afton	Cheboygan	Farm Management	32	32
Bancroft	Shiawassee	Farm Management	43	43
Croswell	Sanilac	Farm Management	20	60
Rives Junction	Jackson	Farm Management	75	75
Michigan Center	Jackson	Farm Management	30	60
Grass Lake	Jackson	Farm Management	25	50
Clio	Genessee	Farm Management	50	50
Cherry Hill	Wayne	Farm Management	65	130
Martinsville	Wayne	Farm Management	35	70
Denton	Kent	Farm Management	37	75
Caledonia	Kent	Farm Management	30	30
East Gilead	Branch	Farm Management	50	50
Quincy	Branch	Animal Husbandry	29	58
Mt. Pleasant	Isabella	Animal Husbandry	24	48
Bethel	Branch	Animal Husbandry	79	158
Kinderhook	Branch	Animal Husbandry	45	90
Nobel	Branch	Animal Husbandry	40	80
Burr Oak	St. Joseph	Animal Husbandry	65	130
White Pigeon	St. Joseph	Poultry	50	50

ONE-WEEK POULTRY SCHOOLS.

Place.	County.	Total enrollment.	Total attendance.
Marlette	Tuscola	234	834
Holland	Ottawa	520	1,720
Flint	Genessee	644	3,644
Battle Creek	*Calhoun*	864	3,800
Chicago, Ill.		1,759	11,159
Grand Rapids	*Kent*	1,580	5,780
Muskegon	Muskegon	844	3,844
Detroit	*Wayne*	1,888	8,888
E. Lansing	Ingham	750	3,750
Chelsea	Washtenaw	603	1.603
Dublin	Manistee	62	362
Hartford	*Van Buren*	354	954

GRAND TOTAL OF ALL MEETINGS.

	Average Attendance.	Total Attendance.
Two-day Agricultural Schools	2,529	9,183
Two-day Home Economics Schools	1,232	4,108
One-day Agricultural Schools	5,593	8,142
One-week Poultry Schools	10,200	46,500
	19,554	67,933

REPORT OF EXTENSION WORK IN FARM CROPS.

BY J. W. NICHOLSON.

Absence of Extension workers who are with the over-seas forces continues to limit the scope of the work of this department. However, all projects started have been continued and in addition some rather detailed cooperative tests have been placed in widely scattered sections of the State to demonstrate the special adaptation of improved varieties of grain.

The Michigan Crop Improvement Association continues an active factor in our extension work. There were organized this year thirteen local associations with one hundred forty members and four hundred sixty state members making a total of six hundred members.

During the past year cooperative tests were carried on with members of the association as follows:

19 tested a half bushel of pedigreed oats.
17 tested a half bushel of pedigreed spring barley.
33 tested a 2 qt. sample of corn.
23 tested a 2 qt. sample of Early Wonder beans.
13 tested a 2 qt. sample of Robust beans.
52 tested samples of soybeans.
10 tested vetch.
2 tested 6 strains of alfalfa.
5 tested Grimm Alfalfa seed.
12 tested Hardy Michigan grown alfalfa seed.

The demand for high yielding good quality seed during the war made heavy calls on our farmers who were growing improved varieties. This demand, which had its inception largely during the war when high production was especially desirable, is continuing and in fact extending, based on the performance of these varieties.

The pedigreed grain project has been adopted by nearly all the county agents and much cooperative work has been carried on through them.

There is now a very extensive correspondence connected with this work. Besides about the same number of letters sent out by the head of the Farm Crops Department to farmers the following number have been sent out by the Crops Extension staff during the last six months:

JANUARY 1, 1919 TO JULY 1, 1919.

Number of first class letters	2672
Number of second class letters	7155

The calls for field work is much greater than the present force can care for.

SUMMARY OF FIELD WORK PERFORMED.

Farms visited	193
Demonstrations held	22
Attendance at Demonstration meetings	265
Lecture meetings	43
Attendance at Lectures	1376
Extension schools conducted	13
Attendance at extension schools	1853

REPORT OF EXTENSION WORK IN SHEEP HUSBANDRY.

BY V. A. FREEMAN.

The extension work in Sheep Husbandry was carried on cooperatively between the Animal Husbandry Division of the United States Department of Agriculture and the Michigan Agricultural College, on the same basis as was established during the previous year.

The same lines of procedure were followed, which were carried on mainly, cooperatively with the County Agricultural Agents and the County Farm Bureaus. The main work was educational along the lines of selection of types, culling, management, and care of the farm flock, although much practical work in assisting flock owners to locate desirable pure-bred sires, and in assisting breeders of pure-bred stock to find a market, was accomplished. Work with the larger sheep farms on ranches in northern Michigan, was on a more individual basis, but most of the work was accomplished through lectures and demonstrations to groups of sheep owners, rather than to individuals.

A study of the development of the sheep ranches was made toward the close of the pasture season, through ranch visits. Winter feeding cost records were also kept as a demonstration, on three large sheep ranches where the entire feed was purchased for wintering large flocks of sheep.

The distribution of work is shown by the following table:

Lectures	70
Demonstrations	30
Farm visits	205
Letters written	773
Miles traveled	739
Days in office	85½
Days in field	206½
Attendance	**4,041**
Attendance	**289**

ANNUAL REPORT COW TESTING ASSOCIATIONS.

BY J. A. WALDRON.

July 1, 1918 there were seven cooperative cow testing associations in operation in Michigan with a membership of 184 farmers owning 2,262 cows. Two associations in Allegan and St. Clair Counties were discontinued before October 1 because of the men in charge entering military service and the lack of competent men to replace them. Eight new associations have been organized during the year, making thirteen in all. Twelve of these are in operation and one will be started about July 20.

The following thirteen cow testing associations were active in Michigan July 1, 1919.

1. Oceana County Cooperative Cow Testing Association No. 1.
2. Eaton County Cooperative Cow Testing Association No. 1
3. Van Buren County Cooperative Cow Testing Association No. 1.
4. Branch County Cooperative Cow Testing Association No. 1.
5. Lapeer County Cooperative Cow Testing Association No. 1.
6. Wayne County Cooperative Cow Testing Association No. 1.
7. Wayne County Cooperative Cow Testing Association No. 2.
8. Northeast Tuscola Cooperative Cow Testing Association.
9. Nashville Cooperative Cow Testing Association.
10. Oakland-Wayne County Cooperative Cow Testing Association.
11. Kent County Cooperative Cow Testing Association.
12. Berrien County Cooperative Cow Testing Association No. 1.
13. St. Joseph County Cooperative Cow Testing Association No. 1.

There were in these thirteen associations July 1, 1919, 349 members with 4,205 cows on test.

A great deal of interest has been manifested in cow testing association work during the past year and the demands for assistance in organizing and for men to take charge have been difficult to meet.

The county agents in the respective counties where associations are located and where organization work is now going forward, have, as in the past, given this work the most loyal support and timely aid during the past year. A greater portion of the increase in number and membership of the associations is due to their untiring efforts.

EXTENSION SCHOOLS.

Instruction was given in six two-day and fifteen one-day extension schools by the extension specialists in dairying during the winter.

Total attendance	2,413
Total number of lectures given	44
Total number of demonstrations given	5

The following table gives a brief summary of the field work of the extension specialist in dairying, other than extension schools from July 1, 1918 to July 1, 1919.

Class.	Meetings attended.	Attendance.	Meetings addressed.	Attendance at meetings addressed.
Conventions: State	3	385		
Local: Cow Testing Association	28	321	23	321
Local: Bull Associations	6	130	6	130
Local: Breeders' and Dairy Associations	8	746	8	746
Local: School	3	93	3	93
Local: Market Milk	5	716	5	716
Local: General Farmers	32	1,297	32	1,297
Demonstrations: Judging	12	1,281	12	1,281
Demonstrations: Testing	1	30	1	30
Fairs: Local	1	350	1	350
Contests: Junior, Boys and Girls	3	163	3	163
Conferences: County Agents	3	125		
Farm Visits made	322			

REPORT OF EXTENSION WORK IN HORTICULTURE.

BY J. T. PICKFORD.

Most of the extension work in now done in cooperation with the county agricultural agents. They have a knowledge of conditions in the county and usually are available to furnish transportation from place to place within the county.

About one-half of the value of an extension worker lies in learning the practices of the best growers and carrying this practical information to others. There are localities which ought to be producing heavily of those fruits adapted to the local conditions, but which instead grow a miscellaneous mass of fruits as well as general farm crops.

A letter has been sent to all county agents outlining a program as follows:

> Survey: To ascertain the status of the Michigan commercial fruit growing business by securing the names of growers, acreage of orchards, age, conditions, amount of each, and variety. The object is to encourage the business in promising locations.
>
> Demonstrations: This includes all field meets where any routine horticultural practice is illustrated. Much interest is shown in these meets, especially when staged at a time not interfering with the rush seasons on the farm.
>
> Projects: The projects include demonstrations which involve time and careful attention to detail. They are for the most part intended as community lessons to promote interest in recent findings of experiment stations as well as other well established facts which are commonly ignored. A list follows:
>
> a. Planting an orchard following latest improved methods.
> b. Applying manures and commercial fertilizers to balance soil needs. Use of water for irrigation during droughts.
> c. Attempting by different practices to locate the specific cause of cases of non-bearing trees.
> d. Individual Tree Production Records as a means of eliminating weak strains within varieties.

e. Landscape Planting for Country Homes. To show by example in communities how easily and cheaply a home can be made attractive, as well as adding much to the sale price of the farm.

f. To make illustrative examples of any good practice, as proper spraying, fertilization, etc.

A project has been started in Van Buren County on two vineyards which will give a good insight into the fertilizer needs of the grape. This in in cooperation with the Van Buren Farm Bureau.

Several orchard projects in fertilization are either under consideration or already started. The results of individual growers along this line are also being given close attention and will become available data.

One project in landscape gardening has been outlined in Clinton county.

Several cases of non-bearing trees are being given attention. The results of fertilization, summer pruning, girdling, etc., will be ascertained.

One orchard is, through the interest of the owner, having individual records kept. A four years record is now available. It is planned to extend this wherever an owner is willing to give it the attention.

A study is being made of orchard cost accounting. Several growers are allowing the use of their books to furnish information.

Cooperation in marketing is always advised but the activity of organizing is left to the Extension Specialist in Marketing.

Pruning demonstrations were held this spring at 32 places. Spraying and grafting were also included at several of these meets. Eighty-six trees were pruned exclusive of many small trees.

SUMMARY.

Farms visited	86
Demonstrations	32
Attendance at demonstrations	557
Lecture meetings	29
Attendance at lectures	1,705

REPORT OF EXTENSION WORK WITH POTATOES AND VEGETABLES.

C. W. WAID.

The Potato Project: The extension work with potatoes was continued during the fiscal year beginning July 1, 1918, in much the same manner as it had been conducted heretofore. Modifications were made to suit changed conditions. Mr. H. C. Moore, who was employed to help in this work, entered the services of the Government and thus his time was lost to this work during the entire year.

Briefly stated, the object of the work is to encourage such practices as will help to bring about:

1. Lower cost of production.
2. Better quality seed and table stock.
3. More stable markets and uniform prices.
4. Greater net profit for the growers.
5. Greater value, per dollar invested, for the consumers.

Some of the specific things which we have been attempting to encourage through the putting into effect of the potato project work are:

Section I—To demonstrate the advantage of:

(1) The tuber unit method of improving the seed.
(2) Hill selection of tubers for seed.
(3) Greening or green sprouting of the seed.
(4) Seed treatment to prevent scab and black scurf, (Rhizoctonia).
(5) Testing different growers' seed.
(6) The proper use of commercial fertilizers.
(7) Close planting on productive soils to increase yield and to reduce the percentage of oversized tubers.
(8) Spraying with Bordeaux to prevent blight.

Cooperation with County Agents: This work has been carried on almost entirely in cooperation with county agents. In each instance the agent selects the men with whom the work is to be done; advertises meetings; and assists the extension specialist in getting to and from the meeting place.

Field Meetings: The number of field meetings which were held during the year was considerably reduced for the season, because of the fact that the growers did not have the time to give to these meetings. There were ten meetings held during the year, with a total attendance of one-hundred fifty-three.

Standardization of Varieties: One of the achievements of the year was the accomplishment of what had been encouraged since the work began in the matter of the standardization of varieties. The formation of the Michigan Potato Growers' Exchange, largely through the efforts of Hale Tennant, was a means whereby it was possible to bring about this result. The exchange which is composed of over five thousand growers, voted to make the late Petoskey (Golden Russet), the standard variety for Michigan in all sections where the soil is of a sandy nature. In this way many of the varieties which had been grown heretofore in certain sections were given up in favor of the late Petoskey.

Cooperation with the Potato Exchange: The potato project work as a whole has received the hearty support of the officers of the Exchange as well as of the individual members of the local exchanges who apparently showed more interest than ever before. Work was also done in an effective manner in cooperation with various Gleaner exchanges.

Field Demonstrations: While it is realized that field demonstrations are among the most important features of the potato work, it was thought best not to urge the growers to engage in this sort of work to any great extent during the period of the war because of the shortage of labor. However, many growers have carried on certain practices which have proved profitable in the previous demonstration work.

Vegetable Work: The demand for work along vegetable lines has been chiefly in connection with the Boys' and Girls' Club work, and the Home Vegetable Garden work. There has been a considreable amount of work carried on in cooperation with the greenhouse men of the state. Such requests for help as came to the office were taken care of through correspondence or personal visits.

Lectures: There were fifty-two lectures given during the year at which a total attendance of three thousand four was recorded. This included the extension schools, institutes and special meetings.

Farm Visits: There were one hundred eighty-eight visits made during the year. Many of these were to call upon greenhouse men and inspect their crops. While it is against the extension policy to carry on work through individuals, there are many cases where it seems this is the logical way to do effective work. By helping certain individuals many nearby neighbors will be benefited.

Correspondence: The amount of correspondence during the year has been very heavy, the extension specialist having practically all of the correspondence in connection with potato and vegetable work.

In addition, timely articles have been prepared monthly in mimeograph form and mailed to each of the county agents. These in turn have been printed in the county agent bulletins, local newspapers, and used in other ways. A large number of articles have been prepared for the use of the publicity department of the College. Many articles have been written for various agricultural papers.

Potato Work in the Upper Peninsula: This report does not include the potato work shich has been done in the upper peninsula. J. Wade Weston has had this work in charge. His report will include the work done there.

ANNUAL REPORT OF EXTENSION SPECIALIST IN MUCK CROPS.

BY EZRA LEVIN.

The muck problems of the State have become more definite and a clear conception of what is to be accomplished can be had from the resolutions adopted by the Michigan Muck Farmers' Association, during their last session which was held Farmers' Week at the College. It was pointed out that the muck problems were distinct from highland problems from almost every point of view, and that these problems could best be solved by men who would give their special attention to muck questions. In Europe they have reached this policy where peat experiment stations are common, and peat research is made a special subject.

The reason for this is apparent when we recognize that in every respect, peat soil differs from high-land soil. To bring this out clearly, it is only necessary to call attention to the actual experience which the writer has had this last year. It was found that not only do the muck farmers of Michigan feel that they have been neglected in the matter of the solution of some of their very important problems, but they have received very often advice which was not accurate nor correct, and which was based on high-land experience.

All muck and peat soils are different from high-land soils in these very essential respects; first, while the problem of deficiency in nitrogen is the serious one in all high-land work, it is not at all a problem on muck and peat soils. In fact, the matter of replacing the rapid release of nitrogen is a problem on muck and peat. Secondly, high-land soils are to a great extent made up of mineral, at least more than 90% is of a material which is practically unchangeable, and which has today, and will have for unlimited years, practically the same general chemical and physical

structure. On the other hand muck and peat are changeable to such an extent that the complete chemical and physical structure of peat soil will be changed completely in one or two years after drainage, fertilization and cropping. Furthermore, there is a deficiency of mineral, not only available mineral, but actual mineral, soluble or insoluble mineral matter. Thirdly, while the problem of organic matter is the basis for the maintenance of fertility in high-land soils, the matter of organic matter is obviously no problem at all on peat and muck soils, which are usually more than 50% organic matter. When we recognize this, and recognize the physical characteristics of muck, sponginess, lightness, high water-holding capacity, and other physical factors which are so entirely different from high-land due to the fundamental physical structural difference between peat and high-land soils, then the questions which would arise, entail a completely new aspect of the various other problems concerning the peat and muck soils. It is essential that this fundamental aspect of the problem be reiterated because upon the understanding of this, depends the proper perspective of our work.

Soil and climate are the basis upon which crops have been adapted to our agriculture. The complete difference of soil conditions in that the entire system of management for the maintenance of fertility of our muck areas is reversed, has been noted. Our muck areas are frosty and the season is limited. Muck farmers have been trying to adapt high-land crops to muck land. Failure after failure has conclusively proved that muck land varieties of general farm crops must be developed and tried out. Enough work has been done by this office to show that the matter of varieties, as far as adaptation to muck land is concerned is an enormous field, which has not been exploited. Such considerations as early maturity, short-straw, grain, grasses adapted to moist conditions, frost-proof crops in general—all these questions have come up as distinctly muck problems.

We have found important relationships between the addition of ferterlizers and the rapid breaking down of new muck. We have worked on the matter of the relations of manure to the development of muck, and its utilization in breaking down the raw muck.

The entire question of intensive truck growing on muck is a subject in itself. We do not recognize sufficiently that Michigan is by virtue of its position, likely to be one of the biggest truck sections in the United States, and our muck is to play an important part in growing this truck. Today we are one of the leading states in the Union in the production of celery and onions, both of these almost exclusively grown on muck.

The matter of varieties, the matter of demonstrations on questions relating to these crops have received the attention of this office and will receive more as this work is given more funds and more men are put on it. We have been marking time this year, as it were, and affirming some of the findings of the last year.

The question of implements is demanding attention. The implements used on high land are not at all adaptable to muck. The tendency for implements to sink in muck makes wide wheels necessary, and implements of low construction which can be easily handled, are demanded. A great deal of work could be done in cooperating with the manufacturers in making tests for plows, and various farm implements on our muck areas; as for example, several of the big muck farms in the State of Michigan today, do not use a manure spreader for the reason that the present

types are not adapted to muck. The various implements used in cultivation should be changed radically for muck use. All these matters will be taken up in cooperation with the Farm Mechanics Department.

Muck problems have become definite through contact with muck farmers through the State, and through contact with the muck demonstrations which were carried on under our auspices in various parts of the State; namely, in Allegan county, Huron county, and Kalamazoo county.

Sooner or later it will be found that it will be advizable to have a muck demonstration farm, upon which these many things could be tried out.

The work is to a great extent unorganized. It should be divided into its two distinct phases, the intensive and the extensive muck farming. The intensive farming is a field which requires a special attention to truck crops and the various problems arising from the truck crops grown on muck. The matter of celery seed, celery varieties, celery diseases, the entire celery problem, could very well use a man continually upon it, and the fact that it represents an industry in Michigan which goes into the millions, is sufficient to urge the appointment of such a man in the near future, who would deal with all the muck problems dealing with muck truck crops. The entire onion question has never been worked out satisfactorily in the State. The growers are ignorant of methods used in other states; they are not acquainted with the storage information, with diseases, and insect control, with handling of muck, etc. They have many problems, and it is my belief that the only way these problems can be handled is through the specialist who is concerned with all the various aspects of the truck crops on muck.

There is the consideration of the extensive muck agriculture which is only a part of the problem of the reclamation and utilization of large areas in the State at present unused. It brings up the problem of the management of these areas, animal husbandry and cropping. According to a careful estimate by United States drainage engineers, there are more than five million acres of muck in Michigan. This office has been giving these matters study. Means should be available for carrying our information to all the counties in the State, rather than to the few counties that we have had time to work in.

To a great extent the time of this office has been taken up with the southwestern counties because of the serious celery problems which have arisen this year, problems which have to do with adulterated seed, diseases, and plant bed failures, consequently my planned efforts in other directions have not materialized. Still, it was possible to carry out several demonstrations which are now growing and seem to indicate very interesting things.

The largest demonstration carried out is a nine acre plat on the Woodward farm in Constantine, where the Muck Farmer's Association will meet for a summer meeting on July 15, and at which time we will go over our problems. We have started a demonstration plat at Traverse City, at the State Hospital. This is the second year of a demonstration plat at Deckerville in the eastern part of the State, which was a complete success in so far that a farmer made the unsolicited statement that that demonstration was the most valuable farm work, and had repaid him more than any work that he had ever done. The results of this demonstration were printed in full in the "Michigan Farmer" and sent to all the members of our mailing list which numbers about nine hundred.

As was mentioned before the Muck Farmers' Association was formed this year, and went on record as requesting the Agricultural College to give more attention to the muck areas of the State. A request was made for a short course along muck lines, which would deal with the handling of soils and management of muck land.

This office continued to handle Camp Custer manure for the farmers of the State, and this work which was outside of our regular work, was the result of utilizing almost fifteen hundred cars of manure at a loading charge of about ten dollars less than the loading charge of manure at Chicago. Not only did it save this large amount of money for the farmers of Michigan, but it also made available this manure at a time when fertilizers were short and no manure was available at Chicago.

Attempts are being made to renew this contract with the Camp authorities so that the farmers may continue to receive this fertilizer.

Considerable work has been carried on, showing the value of the use of muck as a fertilizer. This work, which was begun the previous year, has led to many interesting results. It should be noted that two companies in Berrien county have been formed to sell muck as humus, and the results obtained seem to indicate that these companies are giving full value for money received. Berrien county has been particularly active in the utilization of muck as a fertilizer. Wherever applied under the direction of this office, results have been satisfactory. The possibilities for work along this line are unlimited. It is hoped that this next winter this office can become acquainted with the various counties containing large muck areas, which have not been reached, and work outlined for the following summer.

This work has really been in the formative stage. It must be kept in mind that there is very little literature and very little information available on these muck problems. However, with the experience and active contact with the work in the field and with the big muck farmers, these matters have become crystallized, and I feel that we are now at a point where definite comprehensive activity in the reclamation and utilization of our muck areas should no longer be delayed.

ANNUAL REPORT FARM MANAGEMENT DEMONSTRATIONS.

BY CHAS. GRAVES.

The program of the past year's work covered four principal parts. The first part, The Business Viewpoint, was of general educational nature handled largely through the extension schools and farmers' meetings. The work has been very simple and fundamental. The talks and discussions were illustrated by charts and blackboard work. This phase of the work is considered of vital importance by the demonstrator and especially in view of the fact that very few of the extension workers of the State have had previous training in farm management as a subject.

FARM RECORDS AND ACCOUNTS.

More time has been devoted to Farm Records and Accounts than any other single subject. Two types of account books have been published by the department during the past year. The two account books were of different grades of work. The No. 1 being as simple and elemental as

possible with the aim in view to meet the demand for a beginner's book. This book was distributed through the county agricultural agents and the banks. The No. 2 account book is a complete farm record and includes a complete labor record as well as financial record. This book has been popular among the farmers who wish to study their farm business in more detail than is possible in any other way. This book has been distributed only through the farm management office and the county agricultural agents.

AGRICULTURAL CREDITS.

A credit statement to be used by farmers in asking for short time loans was prepared by the demonstrator and presented to the bankers both by correspondence and at the district meeting of the Bankers' Association. The farm management demonstrator furnishes additional copies to anyone on request.

LABOR EFFICIENCY.

A due portion of time has been devoted to this subject both at extension schools and with farmers on their own farms. The size of farm, arrangement of fields, size of team units, and the efficient use of farm machinery have been emphasized according to their importance for the most economic use of labor.

The policy of the demonstrator has been to work entirely through the county agricultural agents and they have been responsible for the work done in their respective counties.

The demonstrator presented farm management work at five of the county agent conferences held during the past year and spent some time in conference with individual county agents in planning the program to be followed in pursuance of the project.

STATISTICS OF ANNUAL REPORT, FARM MANAGEMENT DEMONSTATIONS, JULY 1, 1918 TO JULY 30, 1919

County.	Account No. 1.	Books No. 2.	Farm Visits.	Special Meetings.	Extension 1-day.	Schools 2-day.
Alger	* 12		13			
Allegan		52				
Baraga	22		13			
Barry	7	12				
Benzie	10	15		1		
Berrien	33	17				2
Branch	20	15	15	1		1
Cass	22	21		2		
Cheboygan		20	1		4	
Clinton	21	27			1	
Delta	28		9	2		
Dickenson	4					
Eaton	5	26	12			2
Emmet	10	20	4			
Genessee		10	4	2	1	
Gladwin		17	5	2		
Iosco		35				
Iron	29		6	1		
Isabella		21				
Jackson	32	3			3	
Kalkaska		26				
Kent	No report.		6		1	
Lapeer	10	13	1			1
Livingston	5	12	5			
Macomb	18					
Manistee	2	14		5		
Marquette	14		11			
Mason	4	14				
Mecosta	17	3				1
Menominee	45	1	5	2		
Missaukee	50	68				
Monroe	5	33	1			2
Montmorency	6	4	8	1		
Newaygo	75	1				
Oceana	61					
Osceola	73					
Presque Isle	11	5				
Saginaw		3		1		
Shiawassee	10	5			2	
St. Clair	10	30	13	9		2
St. Joseph		20				1
Tuscola		20	12	1		
Van Buren		89	17	1		
Washtenaw	7	20				1
Wayne	16	7			4	
Miscellaneous	20	50	15	5		3
Total	714	728	164	35	19	17

REPORT OF EXTENSION WORK IN APICULTURE.

BY EDWIN EWELL.

In the past beekeepers have worked quite independently. Disease became widely spread and ancient methods were used. Only a very small part of the nectar was being secured. The shortage of sugar and the need for a larger production of other sweets, was ground for an appeal to the beekeeper.

Our policy has not been to produce more beekeepers, but to produce better beekeepers. It was evident that this could be accompilshed best through organization and cooperation. It would be as easy to instruct a group as an individual. The work must be educational and requires time.

Many individual beekeepers have been visited in thirty counties of the State, mostly in the southern part. We have worked where traveling facilities were best in order to reach the largest number.

Thirty-two counties of the State now have Beekeepers' Associations:

Bay	Gratiot	Kent	St. Joseph
Branch	Grand Traverse	Lapeer	Saginaw
Berrien	Hillsdale	Lenawee	Sanilac
Cass	Huron	Mason	St. Clair
Calhoun	Ingham	Macomb	Shiawassee
Clinton	Ionia	Monroe	Tuscola
Eaton	Jackson	Oakland	Wayne
Genessee	Kalamazoo	Ottawa	Washtenaw

I attended the State Fair at Detroit, with an exhibit by the State Beekeepers' Association. Also an exhibit during Farmers' Week at East Lansing, and in both places gave almost a continuous lecture on beekeeping.

I have given six addresses on beekeeping in schools, farmers' clubs, and meetings of fruit growers.

I have given addresses at the State Beekeepers' Association Meeting, Short Course in Beekeeping at the Agricultural College, and at a two-day school at Three Rivers, and at a meeting on inspectors at East Lansing.

Forty-five county beekeepers' meetings have been attended and an address given at nearly every meeting and many questions answered. About 1,100 persons were present at these meetings.

The work has gone steadily along during the year, except some interruption caused by the flu epidemic.

Like all educational work, results are most noticeable where the largest number of meetings have been held, and the most work done.

Michigan is an exceptionally good state for beekeeping and there is need for a larger conservation of the nectar that now goes to waste. There is a tendency for a larger number of men to become larger honey producers. Disease is better understood and, if not eradicated, is being controlled more and more and the outlook for larger honey production in Michigan is bright.

REPORT OF EXTENSION WORK IN HOUSEHOLD ENGINEERING.

BY O. E. ROBEY.

The work has been carried out much the same as during the previous year. Since the close of the war, renewed activity has been noted in all lines of work. In fact, the demand has been so great that it has been impossible to give assistance in all places where asked.

EXTENSION SCHOOLS.

As usual the winter months were spent largely in lecturing at Extension Schools. Lectures on both Drainage and Household Engineering were given. During the winter sixteen schools were attended and forty-one lectures were given to an aggregate attendance of 2,274.

HOUSEHOLD ENGINEERING.

The work in Household Engineering has consisted in sending out plans, lectures, and the construction of septic tanks. Twenty septic tanks have been constructed during the year.

DRAINAGE.

The work in drainage has increased rapidly during the year and has gradually widened in scope. A more careful study of this subject cannot help but show the great need in this state for more and better drainage. In a great many cases, it is the fundamental need before good agricultural practices can be applied.

The work has consisted of lectures, surveying fields and farms, giving suggestive layouts for drainage systems, assistance in securing outlets, etc.

In St. Clair county, the drainage work has been carried on in a somewhat extensive manner. This county is especially in need of tile drainage. A large part of the soil is a heavy clay and the last three or four seasons of especially wet weather has clearly shown that satisfactory crops cannot be grown on this land under the present conditions.

A study of the situation in this county showed that in order to make the work most effective it was necessary to carry on an educational campaign and, also, to assist in securing tile and in getting the tile put in the ground.

The educational work has been carried on for the past two years and has begun to show good results. As a continuance of this educational work and in order to bring an object lesson before each community, a series of demonstrations were started this spring in cooperation with the county agents. Fields of twenty-five to forty acres were secured in various parts of the county (about 300 acres in all) for drainage and demonstrational purposes. These fields have been selected so that they can readily be seen from a main road. A large tile drainage machine has been secured to go into the county and tile these fields according to our plans. The work is now in progress and very satisfactory results are expected. A great deal

of publicity has been carried on by Mr. Brody, the County Agricultural Agent, and the papers of the county have cooperated fully in carrying out this phase of the work.

On June 27, 1919, a large drainage demonstration was held at one of the farms. About two hundred people were in attendance. The people attending came from nearly every township in the county. The demonstration attempted to show a practical method of putting in tile by a power machine, as well as methods of laying out farm drainage systems and various technical points important in drainage work.

The tile used in this demonstration work (about fifty carloads) has been bought cooperatively at a saving of over fifty dollars per car. A move is also on foot for buying future orders of tile used in the county in a similar manner.

It is expected that two or three power drainage machines will be purchased, as a result of the demonstrational work, either by cooperative companies or individuals so that the work will be able to continue in the county.

Accompanying this report is a photographic reproduction of a sign used to call the attention of passersby to the demonstration, also a map of the county showing the location of the various plots and a copy of a farm map furnished the farmer who is having the work done.

TRACTOR DEMONSTRATIONS.

During the year assistance has been asked by various county agents in holding tractor demonstrations. Two very successful demonstrations have been held, one at Centreville last fall, at which there was an attendance of about 10,000 people, and one this spring at Coldwater with an attendance of 4,000. The county agents of the counties in which these demonstrations were held deserve a great deal of credit for the great amount of detail work necessary to make these demonstrations a success.

REPORT OF EXTENSION WORK IN FORESTRY.

BY E. C. MANDENBURG.

During the first half of the fiscal year the work was carried on by the staff of the Forestry Department. A number of woodlots were examined and several dune areas were visited and demonstrations held.

On January 1, the specialist resumed work. A hurried general survey was made and a good healthy interest in forestry was found to exist over the whole Lower Peninsula. Numerous requests have been received for woodlot examinations and assistance in marketing woodlot products. Several areas were visited and planting plans and recommendations were made. Over seventy thousand seedlings and transplant trees were planted on three different "sand blow" projects. Two of these were "follow-up" projects while the third was a new one. The preliminary work and examination on this project was made by a member of the Departmental staff. All the planting work in connection with these projects was carried on through the cooperation of farm bureaus and farmers in the immediate vicinity of the Blows. The specialist was on hand to direct the work.

The work in the maple syrup project was advanced by a Round-Up of makers at the College during Farmers' Week, this being the second Annual

Meeting of the association, and by visits to the sugar camps. A keen interest was manifested among the sugar makers in the care and management of the sugar groves and in the application of the new Woodlot Tax Exemption Law of 1917.

Opportunities for addresses concerning forestry and related matters have not been wanting. Talks were made before farmers' clubs, granges, women's clubs and at demonstrations. A number of articles were written for the public press and several county agents having monthly publications were supplied with forestry articles.

Efforts have been made to encourage and assist in every way the various organizations which are interested in highway tree planting. At the last session of the Legislature the Department of Forestry was asked to draw up a bill which would provide for the planting and care of trees on State Reward roads. This bill was passed and signed by the Governor and is now a law. This will greatly aid the development of prettier highways and will be no detriment to traffic but will add much to the pleasure of a drive over these roads.

During Farmers' Week a forestry exhibit was given and particular interest, was manifested in the windbreak exhibit. During the coming year plans are being made to stimulate interest in the planting of shelter belts and in this way to assist the farmer in improving the home surroundings.

SUMMARY OF WORK PERFORMED.

	Number	Attendance
Farm visits	169	
Demonstrations held	11	158
Talks given	19	527
County visits	36	
Woodlots visited (acreage 1,800)	52	
Sand dunes visited (acreage 1,200)	12	
Conferences with agents and others	103	
People served	1,380	

REPORT OF EXTENSION WORK IN DAIRY PRODUCTS.

BY O. T. GOODWIN.

The greater part of the extension work in dairy products has been carried on directly with various dairy manufacturing plants. Most of this work has been directed to the correction of inefficient methods in the plant and the improvement of the finished product.

Instruction has been given in such subjects as the Babcock test, moisture test, moisture control, workmanship of butter, neutralization, starters, manufacture of cottage cheese and ice cream, and the purchase of dairy machinery.

During a portion of the year a survey was made of the creamery conditions in various sections of the State to determine what factors on the plants lead to the farmers being furnished the most satisfactory market.

A certain amount of work has been done among patrons to improve the quality of the raw product furnished dairy manufacturing plants. It is planned to carry on more of this work in the future.

Considerable time has also been spent in conference with officials of the Food & Drug Department in regard to the Babcock Testers' License Law and the method of application.

SUMMARY.

Days in office and laboratory	86
Days in field	106
Dairy manufacturing plants visited	85
Meetings attended	8
Meetings addressed	2
Attendance at meetings addressed	120

REPORT OF FIELD AGENT IN MARKETING.

BY HALE TENNANT.

The work of the Field Agent in Marketing in Michigan during the fiscal year passed may best be described by an account of the activities in the following agricultural industries:

1. Potato.
2. Fruit.
3. Live stock.
4. Milk and other dairy products.
5. Beans and grains.
6. Vegetables other than potatoes.

In the potato industry, the organization of local associations on the plan described in the last report was continued until a sufficient number had been completed to warrant the organization of the central association which was completed on August 14 and 15 at Traverse City, Michigan. This central organization is known as the Michigan Potato Growers' Exchange. This exchange was organized on a strictly cooperative, non-profit, non-capital stock basis, to comply with the requirements of the Clayton amendment of the Anti-Trust Law, so that both local and central organizations should come under this amendment. The relations of the local association to the central organization are very similar to the relations of the individual farmers to the local unit. That is, they are contractual and the fulfillment of the contract is secured by the deposit of a promissory note, the principal function of the central exchange being to supply a sales service for the local members association whose work, in turn, is to assemble, store, grade and load for shipment, the farm products of its members.

The time intervening between the organization of the Central Potato Exchange, and the active operating season which began in October, was devoted to the development of a practical working plan for the organization. Special attention was given to the development of the sales and shipping service. Considerable time was spent in conference with the Board of Directors and officers of the exchange in formulating a definite policy, and also in consideration of the personnel of the prospective sales staff. A trip to Virginia was made to study the sales and shipping methods of the Virginia East Coast Produce Exchange and also in the hope that some cooperative arrangement could be made with that organization relative to some phases of the sales service, especially as regards representation in market. Attention was also given to an accounting system for the central as well as the local organizations, and the services of a representative of the project of the Markets Business Practice were secured.

Considerable work was also done on banking arrangements for the central organization as well as the locals, and a continuous effort was made to enlist the support of the banking and business interests of the section of the State in which the organizations are operating.

The organization of local associations was continued throughout the year. The plan included covering, as far as possible, the northern part of the lower peninsula and also the upper peninsula.

The membership of the Michigan Potato Growers' Exchange at the commencement of the shipping season included the following associations:

Alba Marketing Assn., Alba.
Barker Creek Cooperative Marketing Assn., Barker Creek.
Barryton Cooperative Assn., Barryton.
Bellaire Cooperative Marketing Assn., Bellaire.
Boyne City Cooperative Marketing Assn., Boyne City.
Brutus Cooperative Market, Brutus.
Cooperative Marketing Assn. of Cadillac, Cadillac.
Cedar Produce Exchange, Cedar City.
Central Lake Marketing Assn., Central Lake.
Cheboygan Cooperative Marketing Assn., Cheboygan.
Dighton Cooperative Marketing Assn., Dighton.
East Jordan Cooperative Assn., East Jordon.
Elk Rapids Cooperative Marketing Assn., Elk Rapids.
Banks Township Market Assn., Ellsworth.
Elmira Marketing Assn., Elmira.
Empire Produce Exchange, Empire.
Falmouth Cooperative Marketing Assn., Falmouth.
Otsego County Cooperative Assn., Gaylord.
Garfield Marketing Assn., Fife Lake.
Hart Cooperative Marketing Assn., Hart.
Farmers Cooperative Assn., Kingsley.
Lake City Coöperative Marketing Assn., Lake City.
Levering Cooperative Market Assn., Levering.
Mesick Cooperative Marketing Assn., Mesick.
Manton Cooperative Marketing Assn., Manton.
Mancelona Marketing Assn., Mancelona.
Petoskey Cooperative Market Assn., Petoskey.
Provemont Cooperative Marketing Assn., Provemont.
Rapid City Cooperative Marketing Assn., Rapid City.
Rogers City Cooperative Marketing Assn., Rogers City.
Rodney Cooperative Assn., Rodney.
Farmers' Cooperative Assn., Traverse City.
Wolvérine Cooperative Market Assn., Wolverine.

The enclosed map, marked "Exhibit A," indicates the location of these organizations. On July first, the membership for the Exchange had increased to include the following organization:

Helena Produce Assn., Alden.
Bark River Market Assn., Bark River.
Bendon Produce Exchange, Bendon.
Benzie Farmers' Cooperative Assn., Beulah.
Buckley Marketing Assn., Buckley.
Charlevoix Cooperative Assn., Charlevoix.
Evart Cooperative Shipping Assn.

Gleaner Farmer Produce Co., Fife Lake.
Grant Cooperative Marketing Assn., Grant.
Hobart Cooperative Marketing Assn., Hobart.
Kalkaska Produce Co., Kalkaska.
McBain Cooperative Marketing Assn., McBain.
Millersburg Cooperative Marketing Assn., Millersburg.
Onaway Cooperative Marketing Assn., Onaway.
Posen Cooperative Marketing Assn., Posen.
Cleon Marilla Marketing Assn., Pomona.
Delta Market Assn., Rapid River.
Mason County Cooperative Assn., Scottsville.
Stanwood Cooperative Assn., Stanwood.
Leelanau Potato Growers' Assn., Suttons Bay.
Woodville Cooperative Assn., Woodville.
White Cloud Cooperative Assn., White Cloud.
St. Nicholas Market Assn., Winde.

In addition to the above organizations, the following organizations have been completed and expect to join the Cadillac Exchange in the near future.

Big Rapids Cooperative Assn., Big Rapids.
Cloverland Market Assn., Daggett.
Ford River Market Assn., Escanaba.
Hillman Market Assn., Hillman.
Baraga County Cooperative Assn., L'Anse.
Lake Ann Farmers' Cooperative Assn., Lake Ann.
Lewiston Market Assn., Lewiston.
Marquette Farmers' Market Assn., Marquette.
Schoolcraft County Cooperative Marketing Assn., Manistique.
Baldwin Market Assn., Perkins.
Republic Assn., Republic.
Skandia Market Assn., Skandia.
Shelby New Era Cooperative Assn., Shelby.

The enclosed map, marked "Exhibit B", will indicate the location of these organizations.

There are, in addition to the organizations above listed, a considerable number of prospective organizations, and it is confidently expected to increase the membership of the Potato Exchange to from eighty to ninety organizations during the next fiscal year.

The results of the year's work of the Michigan Potato Growers' Exchange are briefly as follows:

Total number of cars handled........................2,227

In addition to the above, 75 cars of potatoes have been handled since the first of last July, which really should be included in this year's business, making a total of about 2,300 cars.

92,326,000 lbs. of potatoes were sold for......	$1,502,751.34
Sales of products other than potatoes totaled.	306,195.40
Supplies purchased for organization totaled..	68,836.00
Making a total of........................	$1,877,782.74

Another distinct result of the operation of the Potato Exchange was the wide distribution of its products. The 2,300 cars were sold to ap-

proximately 403 buyers, located in all the states of the Union east of the Mississippi except the state of Mississippi, and to several states west of the Mississippi. It is a noticeable fact that very few potatoes of the Michigan Potato Growers' Exchange were sold to the city of Detroit. There was also a noticeable absence of piling-up of potatoes in certain preferred markets. One of the most valuable results obtained by the efforts of the Potato Exchange was the work done in the standardization of the product. It was found that a large number of varieties were being grown in the section, and a still further number of mixed varieties. Consistent effort was made throughout the year to reduce the varieties grown, as far as possible, to the variety known as the Russet Rural, and which has been named by the Potato Exchange, the Petoskey Golden Russet, and it is hoped to eliminate practically all the varieties except this and certain types of round white potatoes which are suitable for the heavy soils.

Not only the elimination of a lot of undesirable varieties, but also the improvement of the varieties recognized, was made a permanent policy of the organization. This improvement of the varieties was carried on under the direction of Mr. C. W. Waid, Potato Specialist of the Michigan Agricultural College, and it is hoped that this work will be continued through the coming season.

Demonstrations were also held throughout the territory of the Exchange by Bureau of Markets inspectors and county agents, to explain the grades and to show farmers the great economic loss occasioned by the lack of proper grading. The results of the efforts of organization along the lines of standardization may be best shown by the fact that out of the 403 customers who bought the Exchange products, all but three have written commendatory letters on the quality of the output is recognized to be of the very greatest importance, and the organization cannot hope to attain any marked success unless its output is of distinctly meritorious quality.

Another result of the operations of the Exchange was a general reduction in the handling cost of potato marketing. The fact that there were practically no cooperative marketing associations in the state during the season of 1918 and that the cooperative organizations operated for the first time on a large scale in the season of 1918-1919, makes it possible to show the results of the organization movement, especially since the United States Bureau of Markets reports were available for at least part of the season of 1917-1918 and the season of 1918-1919. It is regrettable that the reports for 1917-1918 do not cover the whole season, as regards the prices paid the farmers, but these reports do cover the most of April and May in 1918 which are sufficient, we believe, to warrant their being taken as typical for that season, and it can be easily demonstrated that the reports for April and May of 1919 are typical for the whole season of 1918-1919. According to these reports, the average difference between the price paid to the farmer and the price received by dealers and organizations from the 11th of April to the 24th of May in the year 1918 was $.4871 per hundredweight. The average difference between the price paid to the farmer and the price received by dealers as shown by the government reports for the period between April 11 and May 24 of the year 1919 was $.2724 per cwt., making a total reduction in the cost of assembling and sale of potatoes of $.2147 per cwt.

According to the reports of the Bureau of Markets, the State of Michigan has shipped to date something over 11,000 cars, the average weight of

these cars running aroung 42,000 lbs., making a total of 862,000,000 lbs. of potatoes. If this average saving of $.2147 per cwt. were made on this total amount of potatoes, the total saving would be equal to $1,850,714.00. Extended observation would indicate that the price paid by dealers to farmers in the territory not within the influence of the Potato Exchange was considerably less than the amount paid the farmers within the territory in which the Potato Exchange was operated.

The average difference between the highest price paid to farmers and the highest price that the potatoes were sold for during the period described in the year 1918, was $.5203 per cwt. The average difference between the lowest price, as indicated by the government reports, paid to the farmer and the lowest price received by the dealers and other operators during 1918 for the period mentioned was $.4521. Now the average price between the highest price paid to the farmer and the higest price for which potatoes sold during the period mentioned during the season of 1919 was $.1922. The average difference between the lowest price paid to the farmer during the period mentioned in 1919, and the price that the potatoes were sold for by the dealers and the Exchange, as indicated in the government bulletin, was $.3500. While there is no direct evidence in these figures to bear out the conclusion that the low cost was within territory of the Exchange, and that the high cost was in the territory not affected by the cooperative marketing organizations, many observations throughout the state would indicate that this condition prevailed.

It is possible that there may be some other reason than the effect of the cooperating marketing associations, in reducing the marketing cost of potatoes, but that reason is not apparent, and to a close student of the problem, there is little other conclusion possible than that it was the direct effect of the cooperative marketing associations operating at cost, which produced the results above described.

THE FRUIT INDUSTRY.

Marketing work in the Michigan fruit industry was devoted principally to the uniting of organizations already established in the fruit belt. A movement had been under way for several years, among the grape associations of Berrien and Van Buren counties, looking to the formation of a central sales organization. This was practically secured a few years ago by all five of the associations in the field uniting and employing the same sales agency. However, a need was felt of some permanent arrangement between the locals other than above described, and a meeting was held at Hartford early in the year, at which plans were fairly well matured for a proposed federation. As the organization did not contemplate a combined sales service, and interest in other problems affecting the industry was not active, the organization did not thrive as is usual with farm organizations of this type, the principal weakness being that there was not sufficient work to maintain active interest outside of the sales and supply business. As the crop in the grape belt was very light, and the development of the grape juice industry was such that practically all the grapes grown in Van Buren county, and also a considerable portion of the Berrien county output, were absorbed by the juice factories, it becme apparent that the tonnage of grapes was scarcely large enough, especially in years of light yield, to support any kind of a permanent organization, and it became

more and more apparent that it would be necessary to combine all the fruit organizations in the State to furnish sufficient tonnage to properly support a central sales agency.

Consequently plans were developed for the formation of a state-wide exchange which would include all fruit organizations. After a careful study of the situation, it was concluded that the best plan was to effect a reorganization of the Michigan Fruit Packers' Federation. That was accomplished at the annual meeting of the said organization, and the personnel of the management was completely changed. The name was changed to the Michigan Fruit Growers' Exchange, and other amendments to the by-laws and Articles of Association were voted, in order to make the organization satisfactory, particularly to the grape interests. Four of the grape organizations had indicated their willingness to join, and it is hoped that all the fruit organizations may unite on this plan in the near future.

The problem presents many complications, and it is thought advisable not to press the matter at present. The members of the former Michigan Fruit Packers' Federation were all visited in the interests of the formation of a central sales agency. Some efforts had been made along this line the preceding year, but with rather unsatisfactory results. All the member organizations were visited and, with the exception of the South Haven and Fennville Fruit Exchanges, all the organizations have agreed to a central sales plan.

In addition to this work, new organizations are being completed in the northern part of the state, one of which, the Hart Cooperative Marketing Association, has already joined the Michigan Fruit Growers' Exchange. The enclosed map, marked "Exhibit C", indicated the location of the Fruit Growers' organizations in the state, and the location of the central office in Benton Harbor.

LIVE STOCK INDUSTRY.

Interest in cooperative marketing of live stock has been very active, and a large number of local organizations have been completed in the State during the past year.

In response to a general demand coming from local live stock shipping associations throughout the State, an effort was made to organize a state live stock exchange, the purpose of this exchange being to co-ordinate and unify the efforts of the local associations and to mobilize their financial power and strength for the general protection and upbuilding of the industry. Work on this central live stock exchange was delayed until the appointment of Mr. G. C. Raviler as Field Agent in Organization, who was to give special attention to live stock marketing in the State.

In response to a general call, representatives of about sixty-three live stock shipping associations assembled at Lansing on the 20th and 21st of March. A constitution and by-laws were adopted and the following directors elected:

Fred Smith	Grand Traverse County.
H. T. Glezen	Cheyboygan County.
E. E. Compson	Mecosta County..
L. E. Willett	Shiawassee County.
C. L. Harrison	St. Joseph County.
C. E. Beamer	Lenawee County.
Wm. E. Hill	Genessee County.

Mr. C. L. Harrison was elected president; Mr. H. T. Glezen, vice-president; Mr. E. C. Beamer, treasurer; and Mr. L. E. Willett, secretary.

Mr. Raviler is meeting with uniform success in allying the shipping associations with this state association, but on account of the extremely large number of associations and the wide territory included, it may require considerable time to develop a membership sufficient to warrant the taking on of any large economic functions. The enclosed map, marked "Exhibit D," shows the location of the live stock shipping associations that participate in this organization movement. The central office will be located at Lansing, Michigan.

DAIRY PRODUCTS.

The work in this field has been devoted to the study of milk marketing problems, especially with the cooperative distributing plants in the State, and in addition, the Berrien County Milk Producers' Association was organized in the cities of St. Joseph and Benton Harbor for the purpose of distributing milk in these cities on a cooperative basis. This organization is now completed and in operation, having bought out the two competitive plants in the Twin Cities, and the developments along this line are being studied with interest.

Toward the close of the fiscal year, attention of the Field Agent was drawn to the milk distributing area of Detroit by reason of certain petitions being sent to the Bureau of Markets at Washington, requesting a survey in the city of Detroit to ascertain the surplus milk arriving in that city. In anticipation of a re-organization of the Milk Producers' Association of the Detroit area, plans are being formulated for such re-organization.

GRAINS AND VEGETABLES.

In the other fields in the State, notably the beans and grains, and in vegetables other than potatoes, including onions and cabbage, numerous local organizations have been completed, but as yet, no effort has been made toward combination of elevators for the purpose of centralized marketing.

In addition to the work in the agricultural industries above described, numerous conferences have been held with groups of county agents in various parts of the State on numerous marketing problems, and an effort was made to acquaint the county agents with the general marketing program which has been advanced; that is, the organization of agricultural interests of Michigan along the line of the different products. At these conferences attention was often given to the general problem of cooperative marketing as it presents itself in local associations and also the combination of local associations into district or state exchanges.

Addresses have also been made to farmers at numerous gatherings throughout the State, on the general problem of cooperative marketing.

The work of Mr. G. C. Raviler, Field Agent in Organization, since his appointment, has been very satisfactory, and his services will no doubt be of value to the farmers of the State. Mr. Raviler's extended experience in cooperative organization makes his advice of especial value to communities that are attempting cooperative organization, especially those communities that are attempting to combine into one local unit, practically

all of the farm cooperative activities, and as the tendency of the state seems to be in the direction of eliminating unnecessary duplication of farm organizations, especially in the same community, it has been necessary to give special attention to forms for organization of this type.

The following is a list of the organizations which Mr. Raviler has been wholly or partly instrumental in completing since his appointment:

Stockbridge Producers' Association.
Milan Live Stock Shipping Association.
New Haven Agricultural Association.
Dexter Agricultural Association.
Munith Live Stock Shipping Association.
Brooklyn Cooperative Association.
Dryden Producers' Association.
Metamora-Hadley Farmers' Association.
Imlay City Farmers' Association.
Gregory Agricultural Association.
Highland Agricultural Association.
Cohoctah Agricultural Association.
Fowler Live Stock Shipping Association.
Colling Farmers' Elevator Association.
Homer Farmers' Elevator Association.
Scotts Agricultural Association.
Williamston Farmers' Elevator Co.
Detroit Market Gardners' Association.
Belleville Agricultural Association.

REPORT OF EXTENSION WORK IN POULTRY HUSBANDRY.

BY E. C. FOREMAN.

The state wide enthusiasm and interest manifested in poultry production by farmer and breeder, has developed largely as a result of the poultry culling campaign introduced by the present extension specialist, ably assisted by the county agricultural agents of the State, whose keen approval and endorsement has greatly augmented the spreading of the gospel of economic production by disposing of all unprofitable hens.

A conservative estimate of the number of hens culled, during the fiscal year closing June 30, 1919, as a result of this branch of extension work, can be safely placed at the million mark. In adopting a new method of culling or in remodeling old ones, the acid test must be applied in order to demonstrate conclusively the certainty of the work and its practical application. By means of demonstration farms, egg laying contests, and retention of all hens pronounced unprofitable, the true value of this work has been established and the accuracy of this system of culling has been verified.

POULTRY CULLING DEMONSTRATIONS.

This work was conducted almost entirely in cooperation with the county agricultural agents, who arranged the meetings and made it pos-

sible to cover so much territory and get in touch with so many people. At each demonstration point the flock would be culled into two or three grades according to the available buildings and equipment.

A grade—Winter layers, highest yearly record.
B grade—Spring and summer layers.
C grade—Constitutionally poor layers.

Example—one of 480

J. A. Anderson, Cassopolis, Michigan.

	Daily Production, After Culling.
A—140 hens	90 eggs
B—125 hens	30 eggs
C— 85 hens (culls)	0 eggs

Outstanding individuals are banded so that breeding for increased production can be followed at home, rather than purchasing questionable birds at fancy prices from breeders with "paper poultry farms".

DEMONSTRATION FARMS.

There are thirty-two poultry demonstration farms located throughout the State operated under the supervision of the present extension specialist. The results of the work of these various farms have solved many much-disputed questions.

(1) That there is no one best breed of poultry for the State. High and low producers exist in all breeds, there being as great variation within the breed as there is between breeds.
(2) That systematic and intelligent culling is profitable.
(3) That environment is as great a factor as breeding—"We must breed the eggs into the hen and feed them out".
(4) That poultry are profitable when fed high priced grains.
(5) That properly cared for hens will respond to care more quickly and yield a greater profit than any other equal investment on the farm.

EGG LAYING CONTEST.

A pen of Barred Rock pullets were selected by the same system, now being advocated in the State and entered in the Missouri National Egg Laying Contest. As further proof of the reliability of this original system of selection, one pullet laid 105 eggs in 117 days during the winter months; another laid 268 eggs in 10½ months leading all hens in competition in the contest. The pen led the Barred Rock division in the contest.

LITERATURE.

Poultry articles have been supplied frequently for publication in the various farm bureau papers. An Extension Poultry Bulletin is almost completed. Mimeograph copies of feeding rations have been furnished all agricultural agents in the State for distribution.

LECTURE MEETINGS AND EXTENSION SCHOOLS.

Provided an opportunity for follow up work in various communities where culling demonstrations were held. These afforded an opportunity to discuss local problems and enter into the various phases of poultry culture.

SUMMARY OF WORK PERFORMED DURING THE PAST FISCAL YEAR.

	No.	Attendance.	Average Attendanc
Farm visits	583		
Poultry culling demonstrations	480	9,963	21
Lecture meetings and extension schools	118	5,883	49
Fairs (Poultry Judging)	10		
Demonstration Farms	32		
Counties visited	36		
People served		15,846	

The poultry work for women was carried on during the year by Miss Annabel Campbell. The method of work was largely through poultry clubs, nineteen of which were organized with a membership of 250. These clubs meet six times during the year. At these meetings the following topics are studied in season:

1. Incubation and Brooding.
2. Care of Flock.
3. Sanitation and Treatment of Diseases.
4. Culling Demonstrations.
5. Poultry House Construction.
6. Poultry Canning Demonstrations.

During the year 53 lectures were given and 82 demonstrations were held with a total attendance of 1,642.

WAR RECORDS OF EXTENSION WORKERS.

Edward Glen Amos, County Agent: Second Lieutenant, Regiment 62 Field Artillery, 1st Battalion, Battery C. Period of service, one year.

William A. Anderson, County Club Leader: Private, Regiment 128, Battalion 1st, Company C. Period of service, twenty-one months.

Earl N. Bangs, Assistant County Agent: Private, Company C, S. A. T. C., Michigan Agricultural College. Period of service, three months.

Frank C. Brown, County Club Leader: Private, Sector 16th, Battery 63, Anti-Aircraft Division. Period of service, three months.

John H. Carmody, Extension Horticulturist: Qualified for Second Lieutenant, Q. M. Corps, Battalion 310 San. Train, 340 Amb. Company. Period of service, twenty months.

Clarence D. Cook, Assistant Specialist in Live Stock: Sergeant, 310 Supply Train, Company D (Motor Truck). Period of service, nineteen months.

Frank A. Davis, County Club Leader: Private Regiment 15, Battalion V, Company 184. Period of service, eight months.

George D. Gilbert, County Club Leader: Private, Central Officers' Training Camp, Battalion 5, Company 25. Period of service, ten months.

Louis H. Gretton, Specialist in Farm Crops: Chief Gunner's Mate, U. S. Naval Proving Ground. Period of service, seven months.

Wm. H. Kennedy, County Agent: Private, A. & M. Training Detachment, Co. B, College Station, Texas. Period of service, six months.

Carl Knopf, County Agent: 1st Lieut., F. A., R. C., 42nd Class, School of Fire, Fort Sill. Period of service, one year.

Edmund C. Mandenburg, Extension Specialist in Forestry: Duty Sergeant, 330th Field Artillery, First Battalion, Battery A. Period of service, six months.

Don A. Meeker, County Agent: Private, Battalion 4th, C. M. G. O. T. S., Company 15. Period of service, two months.

Lawrence W. Miller, County Club Leader: Officer Candidate Private, Company 4th Co. C. A. C., Ft. Howard, Md. Period of service, four months.

Ellsworth B. More, County Agent: Seaman, 2nd Class, Regiment 22nd, Battalion 1st, Company C. Period of service, five months.

Henry C. Moore, Specialist in Potatoes and Vegetables: 2nd Lieut., U. S. F. A., 32nd A. C. Artillery, Battalion 2nd. Period of service, seventeen months.

Leonard G. Morse, County Club Leader: Corporal, Company B, S. A. T. C. Period of service, six months.

William Murphy, Extension Specialist in Farm Crops: Private, Regiment 11th, U. S. M. C., Second Battalion, Co. H. Began service, July 7, '18. Still in service, June 30, '19.

F. F. Musselman, County Club Leader: Private 158 Depot Brigade, 4th Training Battalion, Company 16. Period of service, five months.

Cecil P. Pressley, County Club Leader: Sergeant, Regiment 47, Battalion 2nd, Company G. Began service, April 29, 1918. Still in service, June 30, '19.

*C. J. Seidel, Assistant County Agent:*2nd Lieut. C. A. O. R. C. Period of service, five months.

Russell S. Simmons, County Club Leader: Sergeant Major, Coast Artillery Period of service, ten months.

Chester A. Spaulding, Assistant Leader Boys' and Girls' Clubs: Chief Quartermaster (Aviation) U. S. N. R. P. C. Period of service, four months.

Glenn O. Stewart, County Club Leader: Officers' Training School, Ft. Monroe, Va. Period of service, four months.

Russell V. Tanner, County Agent: Captain Inf., Regiment 84th Div.—Att. 334-Purdue Univ. Tr. Det., Pratt Inst. S. A. T. C Period of service sixteen months.

Ralph W. Tenny, County Club Leader: Corporal, 214th Field Sig. Battalion, Company A. Period of service, seven months.

Reuben Edwin Trippensee, County Club Leader: Private, Signal Corps, Buzzer School, Company 4th. Period of service, three months.

Frank L. True, County Agent: Sergeant, Regiment, Motor Transport Corps. Period of service, nine months.

John Krammin, County Club Leader.

R. E. Cheney, County Club Leader.

John M. Kuder, County Club Leader.

Floyd Smith, County Club Leader.

Margaret Justin, Asst. Leader of Home Demonstration Agents: Red Cross.

E. C. Lindeman, State Leader, Boys' and Girls' Clubs: War Camp Community Service.

REPORT OF FARM BUREAU AND COUNTY AGRICULTURAL AGENT WORK IN MICHIGAN FOR THE YEAR ENDING JUNE 30, '19.

BY EBEN MUMFORD, STATE LEADER.

The Farm Bureau movement, like the work of many other organizations, was greatly accelerated by the war. The interest of the people in larger and more economical production, in more efficient distribution and in greater conservation of food products, was much intensified. The movement toward organized efforts for the solution of agricultural problems was also greatly stimulated. Within about one year after the United States entered the war, forty-four counties organized farm bureaus and forty-one agents and seven assistants were employed as leaders of the work, making a total of sixty-eight counties having farm bureaus and employing agricultural agents.

The program of work of the farm bureau during the war was based primarily upon food needs and the time of the county agricultural agents, as the representatives of the nation, the state, the county and the various communities was largely devoted to assisting in carrying out this program.

In addition to war work done as agents of farm bureaus, the county agent was also recognized by the other war agencies as one of the county leaders in collecting and disseminating information in regard to war activities and in planning and executing plans relative to the war programs. The county agent cooperated in making food and labor surveys and carrying out the plans of the Food Qdministration, the Federal Labor Bureau the Local and District Draft Boards and the Boys' Working Reserve. They assisted the Department of Agriculture in the distribution of nitrates, the Food Administration in the inspection of threshing machines and the State War Board in the distribution of tractors; they also helped in Liberty Loan, Red Cross and War Savings Stamp Campaigns.

As the work of the county agents centered around war activities during the period of the war, so with the close of the war their time and attention is being taken to a large degree by reconstruction activities as related to agriculture. The agricultural needs and opportunities following the war are many, and are potent forces in shaping the policies and programs of the farm bureaus. Habits of team work started by the demands of the war are continuing in the reconstruction period and the spirit of cooperation intensified by the war is being carried into the efforts to solve the problems that now have to be met.

In the chronological statement of the development of the farm bureau work as given below, the rapid growth after the United States entered the war is apparent; this statement of the development of the work also gives the counties having farm bureaus and the list of agents who have been, or are now employed in the different counties.

CHRONOLOGICAL STATEMENT OF THE DEVELOPMENT OF COUNTY AGRICULTURAL AGENT WORK.

County.	Agricultural Agent.	Date of Beginning.	Address.
Alpena	H. G. Smith	July 1, 1912	Alpena.
	David Woodman	Mar. 20, 1916	
	Frank L. True	Jan. 1, 1918	
	C. O. T. Scheetz	Mar. 1, 1919	
Iron	R. G. Hoopingarner	Sept. 1, 1912	Crystal Falls.
	Dwight C. Long	April, 16, 1918	
Kent	J. H. Skinner	Sept. 16, 1912	Grand Rapids.
	H. G. Smith	Jan. 1, 1916	
	R. G. Carr	Jan. 16, 1919	
Kalamazoo	Jason Woodman	Nov. 1, 1912	Kalamazoo.
Allegan	C. B. Cook	March 1, 1913	Allegan.
	Alfred Bentall	April 20, 1916	
St. Clair	L. V. Crandall	March 1, 1913	Port Huron
	Clark L. Brody	April 1, 1915	
Branch	J. W. Chapin	April 1, 1913	Coldwater.
	C. L. Nash	July 1, 1916	
Saginaw	Earl P. Robinson	April 1, 1913	Saginaw.
	Jesse Stutsman	Sept. 20, 1917	
Houghton	L. M. Geismar	June 1, 1913	Houghton.
Newaygo	H. B. Blandford	June 10, 1913	Fremont.
	Simon Harkema	Oct. 22, 1917	
Gogebic	J. F. Kadonsky	July, 1, 1914	Ironwood.
Wexford	J. F. Zimmer	Oct. 1, 1914	Cadillac.
	G. E. Piper	Jan. 10, 1917	
	Clark D. Mason	Jan. 7, 1918	
St. Joseph	J. M. Wendt	Dec. 15, 1914	Centreville.
Marquette	L. R. Walker	July 1, 1915	Marquette.
Dickinson	C. V. Ballard	July 1, 1915	Iron Mountain.
Lenawee	C. L. Coffeen	Aug. 23, 1915	Adrian.
Ontonagon	R. G. Carr	Oct. 10, 1915	Ontonagon.
Cheboygan	C. H. Knopf	Dec. 1, 1915	Cheboygan.
	I. B. McMurtry	Jan. 22, 1918	
Ottawa	D. L. Hagerman	Jan. 1, 1916	Grand Haven.
Mason	R. V. Tanner	Feb. 16, 1916	Scottsville.
	W. J. Cook	Aug. 20, 1917	
Muskegon	R. L. Olds	March 1, 1916	Muskegon.
Van Buren	T. A. Farrand	March 1, 1916	Paw Paw.
	W. C. Eckard	March 1, 1918	
Berrien	H. J. Lurkins	May 1, 1916	Benton Harbor.
Manistee	Frank Sandhammer	July 1, 1916	Manistee
	C. H. Knopp	Jan. 16, 1916	
Menominee	E. B. Hill	July 1, 1916	Menominee.
	E. G. Amos	Feb. 16, 1919	
choolcraft	E. G. Amos	July 1, 1916	Manistique.
	Geo. F. Kinsting	April 1, 1918	
Missaukee	H. L. Barnum	March 6, 1917	Lake City.
Presque Isle	C. M. Kidman	April 20, 1917	Onaway.
Delta	B. P. Pattison	May 15, 1917	Escanaba.
Wayne	O. I. Gregg	June 1, 1917	Dearborn.
Chippewa	E. L. Kunze	June 11, 1917	Sault Ste. Marie.
Oceana	B. F. Beach	Aug. 15, 1917	Hart.
Tuscola	Alex. MacVittie	Aug. 15, 1917	Caro.
Alger	A. L. Olson	Nov. 1, 1917	Munising.
Barry	R. G. Brumm	Nov. 1, 1917	Hastings.
	R. V. Tanner	Jan. 11, 1919	
Bay	R. D. Harrison, Jr.	Nov. 1, 1917	Bay City.
Clare	W. H. Kennedy	Nov. 1, 1917	Clare.
	M. A. Cobb	Aug. 15, 1918	
Grand Traverse	M. E. Duckles	Nov. 1, 1917	Traverse City.
	Robert A. Wiley	Feb. 15, 1919	
Jackson	E. C. Fowler	Nov. 1, 1917	Jackson.
	J. Vernon Sheap	Jan. 15, 1918	
Luce	M. A. Leach	Nov. 1, 1917	Newberry.
	R. H. Cameron	July, 1, 1918	
Osceola	C. L. Rose	Nov. 1, 1917	Evart.
Shiawassee	D. A. Meeker	Dec. 10, 1917	Corunna.
	H. E. Dennison	April 16, 1919	Owosso.

CHRONOLOGICAL STATEMENT—*Continued.*

County.	Agricultural Agent.	Date of Beginning.	Address.
Antrim	W. C. Cribbs	Jan. 1, 1918	Bellaire.
Calhoun	E. B. More	Jan. 1, 1918	Marshall.
	H. G. Clothier	Nov. 1, 1918	
	E. B. More	March 16 1919	
	Paul C. Jamieson	April 16, 1919	
Cass	David Woodman	Jan. 1, 1918	Cassopolis.
Emmet	Keats K. Vining	Jan. 1, 1918	Petoskey.
Genesee	Sidney S. Smith	Jan. 1, 1918	Flint.
Kalkaska	E. E. Twing	Jan. 1, 1918	Kalkaska.
Roscommon & Crawford	Wm. F. Johnston	Jan. 1, 1918	Roscommon.
Gladwin	Allen B. Schlichter	Feb. 1, 1918	Gladwin.
	C. E. Atwater	April 22, 1918	
Ingham	Frank Seeley	Feb. 1, 1918	Mason.
Charlevoix	C. F. Smith	Feb. 15, 1918	Boyne City.
	C. W. Wing	April 16, 1919	
Washtenaw	H. S. Osler	Feb. 18, 1918	Ann Arbor.
Baraga	Irving Kirshman	March 1, 1918	L'Anse.
Livingston	Fred S. Dunks	March 1, 1918	Howell.
Oakland	C. B. Cook	March 1, 1918	Pontiac.
Midland	W. T. Bandeen	March 11, 1918	Midland.
Lapeer	L. T. Bishop	March 16, 1918	Lapeer
Monroe	Ralph Carr	March 16, 1918	Monroe.
Mecosta	Paul H. Smith	April 1, 1918	Big Rapids.
Otsego and Montmorency	Laurence R. Queal	April 1, 1918	Gaylord.
Eaton	T. A. Farrand	April 9, 1918	Charlotte.
Iosco	C. P. Milham	April 9, 1918	Tawas City.
Montcalm	Gifford Patch, Jr.	April 16, 1918	Greenville.
Isabella	H. D. Corbus	April 19, 1918	Mount Pleasant.
Clinton	P. P. Pope	April 20, 1918	St. Johns.
Leelanau and Benzie	Robert A. Wiley	April 22, 1918	Empire.
Macomb	H. V. Kittle	June 15, 1918	Mount Clemens.
Benzie	J. L. Kraker	Jan. 21, 1919	Beulah.
Montmorency	Howard Hindes	March 1, 1919	Atlanta.
Otsego	Arthur C. Lytle	May 1, 1919	Gaylord.
Ogemaw	W. E. McCarthy	June 16, 1919	West Branch.

ASSISTANT COUNTY AGENTS.

Ottawa	W. F. Van Buskirk	May 1, 1917	Grand Haven.
	D. L. McMillan	Dec. 18, 1917	
	B. O. Hagerman	Jan. 23, 1918	
Allegan	C. L. Burton	Nov. 12, 1917	Allegan.
Van Buren	W. C. Eckard	Jan. 1, 1918	Paw Paw.
	Earl N. Bangs	June 16, 1918	

COOPERATION OF COUNTIES IN FINANCING FARM BUREAU WORK.

The financial support given the farm bureau movement by the Boards of Supervisors of the counties is one of the best evidences of the increasing interest of the people in the work and of their appreciation of its value. Not only were the appropriations increased this year at the October and January sessions of the Boards of Supervisors in counties that have had the work long enough to realize its value, but also in the war-emergency counties where the appropriation of Federal funds have recently been reduced because of the discontinuance of the Food Production Bill, the Boards of Supervisors have increased their appropriations to take care of the deficit made by the reduction in Federal funds. In addition to the funds appropriated by the Supervisors, there has been a considerable addition to the county budget by the increase in the farm bureau membership.

DEVELOPMENT OF THE FARM BUREAU PROGRAM AND ORGANIZATION.

This year has been particularly fruitful in the advancement made in the formation by the farm bureaus of county and community agricultural policies and programs and an organization for putting these programs and policies into effect. In nearly all of the counties there is now a well defined program of work formulated by the people. In putting this program into effect there are three types of committees selected by the people; this form of organization is now in general use and is regarded as fundamental to the more highly developed or special types of farm bureau organization. These committees are as follows: (a) The County Executive Committee or Board of Directors; (b) The Community Committees; and (c) The County Project Committees.

County Executive Committees or County Boards of Directors are now found in practically all of the counties having agents, and in most of the counties these committees are well organized, each member being selected to lead a definite project of the county program. The county program is made by the members of the Farm Bureau at the annual meeting or at special meetings and committeemen are selected on the basis of their interest, experience and ability to act as leaders of projects. On this committee are usually represented the interests of the men, women, boys and girls, thus making it possible to have a unified program and to coordinate all activities through the Farm Bureau.

The community is the fundamental unit of the farm bureau organization and program, and special effort is being made to have each community adopt a program and select a committee to direct the work of the program. Encouraging progress has been made in this type of community activity; programs have been formed and committees selected in 570 communities. This kind of community effort is resulting in greater interest and in more active participation on the part of the people in farm bureau work, and is making possible a much larger degree of service.

Through this type of organization county project committees are automatically created; the leader of a project on the County Executive Committee becomes chairman of the county project committee and his associates are the community committeemen from the communities that have adopted that particular project. In counties where county project committees have met, outlined their project and provided methods for carrying out the details of the project, good results have been secured. Experience has shown that this is a very good method of doing effective project work on a county-wide basis and that the work of such a committee provides an excellent foundation for a special agricultural association to extend the work of the project. The county project committees cooperating with the County Executive Committee provide the machinery for unifying all the activities of the Farm Bureau and for developing better methods of work, based upon the county-wide experience.

The value of the farm bureau type of organization has been demontrated in many ways this year. It discovers and develops the leadership of the people themselves; creates a much greater interest in the work; gives a larger degree of service to more people; coordinates and unifies the agricultural activities of the county and of each community of the county, the Agricultural College and the United States Department of Agriculture; gives the agent a carefully selected and interested Board of Directors and

makes him in reality what the name implies, the agent of the people and of their program of work. With this kind of support, the service which the agent can render is greater and more satisfactory both to the people and to himself. It makes the organization and the activities of the people themselves essential factors in the plan and in the advancement of the farm bureau. The extent of the organization in the different counties and communities so far as it can be stated statistically is indicated by the following table:

FARM BUREAU ORGANIZATION DATA, MAY 1, 1919.

County.	No. of communities in county.	Communities organized.	Paid Members.	Membership fee.
Alger*	15	12		
Allegan*	32	17	275	1.00
Alpena*	11	9	500	1.00
Antrim*	15	13	430	.50
Baraga	11	0	0	0
Barry*	25	9	150	1.00
Bay*	14			1.00
Benzie*	16	16		1.00
Berrien	9	9		
Branch*	15	14		1.00
Calhoun*	25		200	1.00
Cass*	30			
Charlevoix*	12		300	1.00
Cheboygan*	26	19	100	1.00
Chippewa*	28	28		
Clinton*	16	9	300	2.00
Crawford*	8	4	72	1.00
Delta	10			
Dickinson*	15	7		
Eaton*	30	20	300	1.00
Emmet*	16	16		1.00
Genessee*	18	12	500	1.00
Gladwin*	16	14	200	1.00
Gogebic	9			
Grand Traverse*	15	8	300	.25
Houghton	16			
Ingham*	15			1.00
Iosco*	12	3	60	.50
Iron*	18	1		
Isabella*	20		300	2.00
Jackson*	16	12		1.00
Kalamazoo	15	1		
Kalkaska*	8	8	50	.50
Kent*	37	24	450	1.00
Lapeer*	15	10	394	1.00
Lenawee*	30	17		2.00
Livingston*	16	3	35	1.00
Luce	6			
Macomb*	20	5	200	1.00
Manistee*	17	14	725	.50
Marquette	24	13		
Mason*	18	18	75	1.00
Mecosta*	12	5		1.00
Menominee	33			.25
Missaukee*	25	19		1.00
Monroe*	15	8	280	1.00
Montcalm*	24	12	350	2.00
Montmorency*	10	6	150	.50
Muskegon	20	4		1.00
Newaygo	26	11	158	1.00
Oakland*	30	30	400	1.00
Oceana*	23	23	500	1.00
Ogemaw*	8		300	2.00
Osceola*	20			
Otsego*	20			1.00
Ottawa*	36	25	90	1.00
Presque Isle*	12	12	325	1.00
Roscommon*	10	2	20	1.00
Saginaw*	28	2	225	1.00
St. Clair*	15	10		1.00
St. Joseph*	16	1		
Schoolcraft*	11			1.00
Shiawassee*	18	7	375	1.00
Tuscola*	15	8	800	1.00
Van Buren*	35	4	40	1.00
Washtenaw*	25	5	50	.50
Wayne*	20	8	311	1.00
Wexford*	18	3	70	1..0

(*) Indicates County Extension Committee organized and projects assigned to each member.

FARM BUREAU ORGANIZATION DATA, MAY 1, 1919

In the development of the farm bureau program and organization, the district conferences of farm bureau officers or other representatives, and the county agents have been important factors. The following conferences have been held:

Marketing:
- a. Kalamazoo, July 23, 1918.
- b. Howell, August 13, 1918.
- c. Saginaw, August 14, 1918.

Program of Work and Study of Experiment Station Results:
- a. Chatham, August 8, 1918.

The County Executive Committee, and the Farm Bureau Program of Work for 1919:
- a. Cadillac, November 25, 26, 27, 1918.
- b. Jackson, December 16 and 17, 1918.

State Farm Bureau Organization:
- a. Michigan Agricultural College, February 6 and 7, 1919.

Methods of carrying out projects for definite results, and relation of Farm Bureau to special agricultural associations:
- a. Petoskey, March 7, 1919.
- b. Big Rapids, March 11 and 12, 1919.
- c. Kalamazoo, March 13, 1919.
- d. Saginaw, March 18, 1919.
- e. Michigan Agricultural College, March 20 and 21, 1919.

The Community Organization and Program; also plans for grasshopper control. (For agents of Upper Peninsula and northern district of Lower Peninsula.):
- a. Kalkaska, May 6 and 7, 1919.

The Community Organization and Program:
- a. Grand Rapids, May 8, 1919.
- b. Flint, May 13, 1919.

As will be seen from the subjects discussed at the above conferences, the time was given largely to questions of the farm bureau program and organization. In addition to these questions, the marketing, potato, pedigreed seed, farm management, grasshopper, and sheep projects have been given special attention. A new feature of these conferences has been the attendance of farm bureau officers or other representatives from the County Farm Bureau. These representatives have taken an active part in the discussion and the conferences have been of much greater value because of their participation.

SPECIAL AGRICULTURAL ASSOCIATIONS.

The Farm Bureau is proving to be the central agricultural organization of the county through which interest in special agricultural projects is discovered or developed. In the beginning this interest may be entirely unorganized, but through farm visits by the agent, demonstrations or county or community meetings of the people it becomes represented on the county program or on community programs by committees; plans for the development of the project are then outlined, and with the growth of

activities connected with it, a special agricultural association is formed. It is in this way that the Farm Bureau has assisted in the formation or reorganization of the following special organizations this year: 70 potato; 38 farm loan; 21 pure seed; 18 threshermen's; 17 milk producers'; 6 beekeepers'; 24 livestock shipping; 107 marketing; 12 cow testing and 39 community breeders' associations.

For the greatest degree of success both of the Farm Bureau and of the special agricultural associations, it has been found necessary to have the work of the Farm Bureau and the special associations closely coordinated, and in several of the counties, steps have been taken in this direction. Most of the problems of the special associations are fundamentally of an educational character and their members are recognizing this and willingly becoming members of the Farm Bureau.

FORMATION OF THE STATE FARM BUREAU.

Another step in the federation of associated efforts in agricultural development was the formation of the Michigan Farm Bureau in February. This organization is composed of counties having Farm Bureaus cooperating with the Michigan Agricultural College and the United States Department of Agriculture. It has adopted a State program and has elected a head for each department of the program; each department head selects two associates and the departmental committee formed in this way outlines the departmental project and cooperates with the project committees of the County Farm Bureaus in developing such projects as have a territorial application larger than the county. State Farm Bureaus have been formed in fifteen states and steps have been taken to organize a National Farm Bureau in November.

THE USE OF DEMONSTRATIONS AS A METHOD OF FARM BUREAU WORK.

The use of the demonstration on the farmer's own farm has always been a leading method of Farm Bureau work. Experience has proved the value of this method, based as it is upon sound pedagogical and psychological principles. The principle of learning to do by doing is used under conditions which the farmers themselves have to meet and their attention and interest is secured not only by listening, but also by seeing and doing. The reports for the last calendar year show that 5,297 demonstrations were conducted, that there was an attendance of 39,235 at demonstration meetings and that the profit resulting from the work in 37 counties, on demonstration units alone, was $355,710 or considerable more than the total cost of the work.

STANDARDIZATION PROJECT.

Among the outstanding results of the work in Michigan the standardization project and the projects associated with it deserve special mention. This applies both to work in relation to crops and live stock.

A. Crop Standardization:

The standardization work on crops has been made possible by the variety tests based upon the work in plant breeding of the Experiment

Station and the cooperation of the Department of Farm Crops. The history of this work has been given in previous reports and it is only necessary to note here some of the important features of this year's activity.

Rye: Rosen Rye easily ranks first in extent of grain standardization. In many counties it has become the principal variety and the chief problem now is one of maintaining a larger degree of purity of the variety. All of the agents have had success with Rosen Rye demonstrations and their reports show that an estimated increase of five bushels per acre of Rosen over common rye is very conservative. On this basis the increased yield due to the Rosen rye project in the State this year is more than 1,000,000 bushels.

Wheat: The value of standardization as applied to wheat has also been demonstrated largely through the merits of Red Rock. While unfavorable weather conditions seriously injured the crop of 1918, yet in several counties this variety proved its superiority and a large acreage was again sown. The most important fact in this relation is the increasing interest of the farmers in better varieties and in the value of standardization of those varieties when once thoroughly tested and found superior.

Oats: Variety test of oats have been made under the direction of nearly all the agents with the result of a growing interest in the pedigreed strains that have been developed by the Experiment Station. The demonstrations in practically all cases have shown the superiority of the pedigreed varieties and the acreage, of these demonstrations, has been greatly increased.

Corn: The extremely serious seed corn situation of last year resulted in a much greater interest on the part of the corn growers in finding the variety best adapted to local conditions. The more than 100 cars of corn imported into the State for seed did much toward saving the situation so far as seed was concerned, but the fact that it failed to mature in so many instances, even with a favorable fall, fixed the attention of the farmers as nothing else could have done, on the value of variety. Accordingly, the variety tests conducted by the agents this year have had much attention and the foundation has been laid for excellent work in corn variety standardization based on local needs.

Potatoes: Among the many valuable phases of the recent organized movement of the potato growers, the rapidly growing interest in standardization of varieties is notable. The experience in marketing cooperatively brought to the attention of the growers very forcibly the knowledge that reduced prices and other important losses could be directly attributed to the fact that 80% of the cars shipped were of mixed varieties. It was the learning of these conditions by close touch with the marketing process that fixed the attention of nearly all members of the potato marketing associations on the Farm Bureau program of standardization, and led to the adoption of the Rural Russet for the Southern Peninsula and the Green Mountain for the Northern Peninsula.

Barley: The seed corn situation of last year also increased the growing of barley, and here again was noticeable the large number of requests made to the agents to secure pedigreed varieties and the degree of standardization of this grain is probably second only to that of rye.

Beans: The growing of beans shows the same increasing interest everywhere in securing better varieties, the Early Wonder and the Robust being widely used by the agents in variety test work.

B. Live Stock Standardization:

The program for standardization of breeds of live stock by communities, counties or larger districts, is older and better established than that for standardization of crops, but live stock standardization is only in its infancy. Every agent is working for the elimination of scrub sires and the substitution of pedigreed sires and every year several breeders' associations of community or county extent are formed. This year from reports available it is shown there were introduced on the suggestion of the agents, 197 registered bulls, 318 registered cows, 140 registered rams 106 registered boars, and that 268 registered sires were transferred from one community to another. In addition to the introduction of pure bred sires which is usually on the basis of standardization of breeds by communities there were formed 39 live stock breeders' associations whose purpose is primarily that of standardization.

SOILS.

The soil project in its different aspects has always been a fundamental one and the work has been continued as outlined in previous reports. It includes the supply of humus; use of marl, lime and fertilizers; drainage; land clearing; and work with muck soils. On the suggestion of the agents, as shown in reports available, 458 crop rotation systems and 103 drainage systems were planned and adopted; 4,763 farmers reinforced manure with acid phosphate or ground rock phosphate; 4,682 farmers used chemical fertilizers totaling 8,757 tons. 183 marl beds were located, and as a result of demonstrations, the use of marl and lime has become so general that it is practically impossible to give an adequate statistical statement of the amount used. Another interesting fact related to soil demonstrations is the report of 12,038 acres of clover and other legumes plowed under for green manure on suggestion of the agents. In several counties special work, based on results of surveys made by the Department of Soils, is being done in cooperation with that department. This work promises to be of great value to the farmer.

FARM CROPS.

Corn: The difficulty of getting good seed corn last year has had a a great influence on all phases of the corn project as well as the question of standardization discussed under that heading. Seed selection and testing have always been important Farm Bureau projects, but the experience of last year has tended to make both of these activities much more general. In accordance with Farm Bureau corn projects, 13,982 farms selected seed, 12,818 tested for germination and 10,297 grew corn for silage.

Wheat: The treatment of seed wheat for control of smut has been one of the most important wheat projects for this year. 201 demonstrations are reported. Special effort was made to eliminate causes of damage from the treatment such as occurred the previous year. The wheat variety project has been referred to under standardization. The fertilizer project in relation to wheat has been continued, particularly the demonstrations in the use of acid phosphate.

Oats: The chief oat projects were variety tests referred to under standardization, of which 184 are reported, and smut control demonstra-

tions of which 173 are reported. The treatment for control of smut has now become so general in some counties that it is no longer made a specific part of the oat project.

Potatoes: The potato project with its various phases has become one of the standard State projects and one upon which much work has been done. 37 counties report a total of 609 potato demonstrations; following suggestions of the agents, seed potatoes were treated for disease on 2,304 farms and 57,472 acres were planted with treated seed. Green sprouting demonstrations produced good results in practically all instances. Both hill selection and tuber unit demonstrations were conducted and the interest in selection of seed has greatly increased. The variety test and standardization phases of the project have been referred to.

Alfalfa: Alfalfa has been an important Farm Bureau project from the time county agent work was started in Michigan. The alfalfa campaigns of 1913 conducted under the direction of the agents served to attract state-wide attention to the value of this legume although doubtless many failures resulted because some of the conditions necessary to success were not carried out. Since the campaigns of 1913 there has been a gradual increase in the interest in alfalfa growing, due largely to the demonstration work conducted under the supervision of the agents. 155 demonstrations have been reported this year and doubtless this is considerable below the actual number. It is in this way that information as to the successful methods of growing alfalfa has been spread. The acreage has also been increased because of the aid given by the agents in securing good seed, lime, marl, and inoculation for the farmers.

Other legumes: The work on red and alsike clover is always an important project, the reports showing that it included 16,475 farms, affecting about 125,319 acres. The soy bean project continues to grow, 201 demonstrations being reported, including 939 acres. There were also 122 sweet clover demonstrations, or about 940 acres and 94 winter vetch demonstrations including 615 acres.

FRUITS.

The various fruit projects have always occupied much of the attention of the agents in the fruit sections of the State and again this year have had an important place in the Farm Bureau programs of those counties. The fact that the fruit growers have had a good State organization for many years and local organizations in several counties has made all Farm Bureau fruit projects more effective; and through their organizations leadership had been developed and the fruit growers have taken a very active interest in the Farm Bureau project, which accounts for the large amount of Farm Bureau work that has been done in horticulture. The work has been continued this year in much the same way as outlined in previous reports.

CONTROL OF INSECTS AND OF PLANT DISEASES.

The control of insects and plant diseases is always a major project in every Farm Bureau program. The work done in the control of grain smuts has been referred to, and every year receives much attention. This year all of the agents have assisted in the campaign for the eradication of the high Bush Barberry and the purple-leafed Barberry.

Another project that deserves special mention is the grasshopper control work. As a result of the very successful control work done in Kalkaska county last year, the visits of farmers in nearby counties to see these demonstrations, and the explanation by the County Agent and the Department of Entomology of the methods used, twelve counties in that section of the State made appropriations this year for the purchase of poison to control grasshoppers. Methods of Farm Bureau organization for use of the poison and making the control work thorough, were discussed at two of the district conferences. These plans were put into effect and the savings to the farmers of that section of their State have reached several hundred thousand dollars.

LIVE STOCK.

There are several important live stock projects that form a part of almost every Farm Bureau program; among these are the effort to eliminate scrub sires and substitute the best pedigreed ones that can be obtained; the organization of cow-testing, live stock shipping, sheep and wool growing, and breeders' associations; the more economical purchase and use of feeds; the control of disease and the improvement of marketing conditions and of credit facilities for the purchase of better live stock.

In addition to the work referred to under the live stock standardization project, nine cow-testing associations were formed and 2,506 cows tested through such organizations; also 1,454 were tested by the agents or at their suggestion, and as a result of the testing work there were reported 298 cows as discarded. Balanced rations were figured for 503 farmers and adopted by them; 637 animals were tested for tuberculosis by the agents or on their suggestion and 25 treated for blackleg; 214 hogs were vaccinated by the agents and 9,333 by veterinarians or farmers on the suggestion of the agents or as a result of the cooperation of farm bureau members in carrying out this project. 249 silos were secured and assistance given in planning barns and other farm buildings.

POULTRY.

A large amount of work has been done on the poultry project in cooperation with the Poultry Department. More than 200 culling demonstrations were reported for 1918. They have been the means of eliminating a large number of unprofitable hens and of greatly increasing the interest in better poultry. The other poultry projects have been continued as outlined in last year's report.

FARM MECHANICS.

Several tractor demonstrations have been conducted under the auspices of the Farm Bureau; these have been conducted on an educational basis and the large attendance even in a very busy season is evidence of the value the farmers attach to such demonstrations and of their interest in knowing more about the merits of this new source of power. In cooperation with the Department of Farm Mechanics, assistance was given in the installation of 133 water supply and sewage disposal systems. The rapidly growing use of machinery on farms and in farm homes tends to increase the amount of work on projects in Farm Mechanics. The assistance given in planning buildings and other farm structures continues as outlined in previous reports.

FARM LABOR.

Several of the counties report greater difficulties in securing farm labor than ever before. The number of applications made by farmers for laborers for the calendar year 1918 was 5,197 and the number located through the Farm Bureaus was 3,476. The number of men applying for work was 2,921; women 255. In several instances the agents also acted as county directors of the Boys' Working Reserve and the reports show that the work of the boys, many of whom were placed on farms, was satisfactory. The labor survey has been used rather extensively as a guide to the labor needs of the farmers of the counties. The farm labor project is highly valued by the farmers and the methods of handling it will doubtless be developed and made more efficient.

FARM MANAGEMENT.

The farm management project is a part of nearly every farm bureau program and should occupy a prominent place in such programs as it tends to give a balanced relationship to the enterprises of a farm and concentrates attention upon the farm as a unified business. The increasing interest in the cost of production studies is shown in the number of farmers using farm account books, the reports showing that 11,804 books were placed; 322 farm management demonstrations are also reported.

MARKETING.

As stated in the section on Farm Bureau Program and Organization the making of a program by the people of the county and of each community is a fundamental part of the farm bureau plan. In the making of this program by the farmers, almost invariably the first project mentioned is the need for better methods of marketing. The interest in finding successful methods of collective buying of farm supplies and of collective selling of farm products is very strong and in practically every farm bureau program this project occupies a leading place and is receiving much of the attention of the farm bureau members, committeemen and county agents. In the commercial potato districts, the marketing project this year was a major one for all the Farm Bureaus and the agents. They have cooperated with the Field Agent in Marketing and with the officers of the Michigan Potato Growers' Exchange in the formation of 70 local associations. The experience of these organizations in selling potatoes has led to a much greater interest in all of the other phases of the Farm Bureau potato project. The growers are realizing as never before, the need of standardization of varieties, of selection and treatment of seed, of inspection for control of disease and elimination of foreign varieties and of all of the other factors in the potato project that lead to successful and economical production and marketing.

Just as the participation in the marketing of potatoes has led to greater interest in every other step in a successful potato business, so has the organized participation in the marketing of other products led to a realization that success in selling depends upon several factors. In other words, the farm bureau program is bringing about a realization of the fact that growing the product and marketing it are not two separate processes, but that they are but two phases of one process and that the greatest success of either calls for close inter-dependence of both.

Some of the other farm products or farm supplies for which the farm bureaus and agents have assisted in forming cooperative buying and selling associations are live stock, grain, feed, fruit, tile, wool, cabbage, swine, and farm machinery.

BOYS' AND GIRLS' CLUBS.

As noted in last year's report an effort is being made to build a unified agricultural program in each county through the farm bureau and to coordinate the projects of the boys and girls with those of the adults. This is making a much stronger program and a better organization. Most of the agents devote considerable time to Club Work and when there is no Country Club Leader, they assume the responsibility for the development of this work. This year, they assisted in the formation of 782 clubs with a membership of 11,484; they also aided in carrying on the different club projects.

The work of the women is also being made an organic part of the farm bureau program and organization. The county agents have recognized the value of the home demonstration work and have assisted in organizing it and developing the various projects connected with it. Experience in building the Farm Bureau all points in the one direction of the need of constructing a program where the projects of the men and the women are unified and re-enforce one another. Cooperation is needed in carrying on these two phases of farm bureau work if the largest degree of success is to be attained.

EXHIBITS AND FAIRS.

The exhibit is regarded as an essential part of a complete program of farm bureau work and this project has been carried on much the same as outlined in previous reports, but with a growing interest and participation in it by the people themselves.

WINTER MEETINGS.

Changes growing out of farm bureau experience are being made in the character of the winter meetings. The organization and work of the farm bureau committees are the chief factors in bringing about these changes. The winter meeting is becoming the means for considering the data collected from the various Farm Bureau projects as a basis for the work of the coming season. The various committees that have been conducting demonstrations or doing other work on specific projects during the year become the nucleus of a new kind of winter meeting—a meeting of men or women well informed on the special projects to which they have given much attention and, therefore, a meeting eager for a discussion of the more special problems and difficulties connected with their project and not to discuss the more elementary or general phases of it. It is a meeting primarily for planning another year's work in the light of the experience of the past; a meeting not for entertainment, but for working out better methods for more highly specialized and efficient activity in carrying on a particular farm enterprise, or the farm as a business unit, or some form of cooperative activity. Such a meeting calls for a specialist and at such a meeting the specialist finds one of his best opportunities to render service.

WAR EMERGENCY WORK.

As stated earlier in this report the character of the farm bureau work undertaken during the past year was very largely influenced by the needs arising from war time conditions. A few of the results reported indicate the scope of the work accomplished upon recommendation by the agents, or through their efforts.

No. of farmers assisted in securing or locating seed	28,360
No. of bushels of seed secured or located for farmers	153,235
No. of additional acres seeded as result of special production campaign	173,587
Estimated total production on additional acres in bushels	2,006,294
No. of bushels of seed corn saved for 1919 planting	169,454
No. of persons assisted with home garden work	7,853
No. of applications for farm labor	5,197
No. of persons applying for work	3,176
No. of men and boys placed on farms	3,476
No. of farmers assisted in securing fertilizer	652
Tons of fertilizer secured	19,382
No. of sheep placed on farms	2,454
Increased number of live stock on farms:	
Cattle	2,220
Hogs	4,241
Sheep	6,925
Poultry	6,198
Increase of acreage of farm crops due to use of tractor	12,110

RELATION OF FARM BUREAU WORK TO OTHER PHASES OF THE EXTENSION SYSTEM.

A main source of strength of the farm bureau is the recognition that a well balanced agricultural program should take into consideration the community, county, state, national and international phases of our agricultural problems and that the machinery for carrying out this program should be such as can use the united thought and effort of representatives of all these phases of the agricultural situation. The cooperating parties in farm bureau work in the county, the Agricultural College and the United States Department of Agriculture, so the farm bureau representing these three factors is in a position to use the concerted efforts of these parties in the building and execution of a program. The county agent is the representative of these parties and being permanently located in the county becomes a specialist on its needs and its resources for meeting those needs. To supplement his efforts there are the specialists of the Agricultural College and the United States Department of Agriculture and the Committeemen and other leaders and workers of the farm bureau. The development of the county leadership and organization has been described and it is gratifying to note the gradual development there has beenin the service rendered by the specialists of the other cooperating parties, the Agricultural College and the United States Department of Agriculture. The following table gives the number of specialists that have visited each county this year. The total number is 1,647, whereas last year it was 1,332 and the previous year 716. The results of farm bureau work given in this report have been brought about by the cooperation

and it is a pleasure to express here our appreciation of the assistance that has been given by the various departments of the College and their Extension Specialists as well as of the assistance given by other State Departments and by the representatives of the United States Department of Agriculture. The following table gives the statistical statement of the visits of specialists to the different counties.

County.	Months reported.	No. of visits.	County.	Months reported.	No. of visits.
Alger	6	9	Lapeer	10	21
Allegan	11	43	Leelanau	....	3
Alpena	6	9	Lenawee	8	23
Antrim	5	12	Livingston	8	24
Baraga	4	10	Luce	3	5
Barry	8	27	Macomb	9	23
Bay	8	22	Manistee	8	19
Benzie	4	8	Marquette	7	20
Berrien	11	77	Mason	5	10
Branch	10	30	Mecosta	6	9
Calhoun	10	41	Menominee	5	13
Cass	11	38	Midland	3	5
Charlevoix	4	8	Missaukee	6	10
Cheboygan	10	20	Monroe	7	12
Chippewa	5	7	Montcalm	8	20
Clinton	8	27	Montmorency	1	1
Crawford	5	8	Muskegon	8	21
Delta	6	10	Newaygo	8	19
Dickinson	5	7	Oakland	9	36
Eaton	10	39	Oceana	7	15
Emmet	5	14	Osceola	7	8
Genesee	8	21	Ottawa	10	29
Gladwin	5	5	Otsego	4	6
Gogebic	2	3	Presque Isle	6	14
Grand Traverse	8	14	Roscommon	2	3
Houghton	3	5	Saginaw	11	50
Ingham	7	30	St. Clair	10	30
Iosco	5	6	St. Joseph	10	27
Iron	4	5	Schoolcraft	5	7
Isabella	6	20	Shiawassee	6	19
Jackson	11	63	Tuscola	8	20
Kalamazoo	11	77	Van Buren	11	29
Kalkaska	5	9	Washtenaw	10	37
Kent	11	150	Wayne	11	156
			Wexford	11	38
Total number of visits					1,647

FIELD WORK OF ASSISTANT STATE LEADERS AND STATE LEADER.

The field work of the Assistant State Leaders and of the State Leader has followed the outline as given in the reports of the two preceding years. Mr. Earl P. Robinson resigned January 1, 1919 to become State Leader in New Hampshire. Mr. Frank Sandhammer, Agricultural Agent in Manistee County was appointed Assistant State Leader, January 1, 1919.

Mr. J. W. Weston Assistant State Leader for the Upper Peninsula, made 118 visits to counties having agents. He helped to conduct 51 meetings with a total attendance of 4,531.

Mr. Earl P. Robinson made 52 visits to counties having agents and 9 visits to counties without agents. In this work he addressed 39 meetings with a total attendance of 1,045.

Mr. H. B. Blandford made 146 visits to counties having agents and 2 to counties without agents. He helped to conduct 24 meetings with a total attendance of 1,746.

Mr. Frank Sandhammer made 66 visits to counties having agents. In doing this work he addressed 82 meetings with a total attendance of 3,096.

In field work the State Leader has made 122 visits to counties having agents and 3 visits to counties without agents. In this work he has addressed 126 meetings with a total attendance of 15,434.

STATISTICAL SUMMARY OF OFFICE AND FIELD WORK.

In concluding this report we give a statistical summary of some of the important phases of the office and field work of the county agricultural agents.

STATISTICAL SUMMARY—OFFICE.
From July 1, 1918 to June 1, 1919.

County.	Months reported.	Days in office.	Calls on agent.	Telephone calls.	Letters written.	Copies of circular letters mailed.	Articles in local press.	Bulletins distributed.
Alger	11	131	125	729	1,256	5,941	9	1,519
Allegan	11	108½	1,983	1,491	2,851	4,733	44	....
Alpena	4	53½	177	249	195	4,531	15	35
Antrim	11	109	102	133	423	8,783	26	1,265
Baraga	11	117½	140	276	622	2,161	12	2,138
Barry	11	123½	1,090	894	1,057	851	54	7,718
Bay	11	206½	961	774	829	1,932	13	1,887
Benzie	5	74½	325	299	417	1,278	57	589
Berrien	11	124	2,043	3,518	1,966	1,796	113	2,366
Branch	11	124	396	430	695	3,952	72	205
Calhoun	10	137	966	1,373	1,190	148	138	4,621
Cass	11	108	1,093	1,179	897	2,996	32	2,317
Charlevoix	10	108½	798	824	657	6,828	122	1,100
Cheboygan	11	121	677	1,249	761	1,426	73	672
Chippewa	11	117½	895	565	1,448	1,553	88	436
Clare	2	12½	49	41	75	....	10	100
Clinton	11	142	1,050	1,349	640	8,213	48	4,137
Delta	11	130	424	1,242	1,898	3,152	56	592
Dickinson	11	118½	391	489	315	1,811	33	102
Eaton	10	165½	1,163	867	1,714	1,221	156	1,139
Emmet	11	85½	319	790	1,404	7,594	34	312
Genesee	11	131	1,405	1,346	655	6,966	31	776
Gladwin	11	166	968	408	608	2,530	67	1,990
Gogebic	11	93	704	868	1,377	75	43	759
Grand Traverse	11	136	708	685	1,004	13,441	73	857
Houghton	5	15½	66	303	325	....	19	360
Ingham	9	186½	578	652	596	11	11	297
Iosco	11	192	340	340	1,185	4,187	4,382	4,217
Iron	11	133	210	366	1,241	5,499	73	4,316
Isabella	11	130	740	1,241	631	6,278	31	855
Jackson	11	146	1,847	1,493	763	6,257	111	4,088
Kalamazoo	11	148	624	6	643	627	3	18
Kalkaska	11	113½	234	201	632	288	20	345
Kent	11	145½	810	1,156	1,115	4,171	73	....
Lapeer	11	154½	554	231	918	2,825	31	1,093
Leelanau	2	10½	16	25	20	....	1	....
Leelanau and Benzie	7	56½	36	71	693	1,798	118	....
Lenawee	11	155	1,727	2,176	1,044	2,090	118	880
Livingston	6	46½	152	119	205	350	36	237
Luce	10	136½	804	750	1,551	946	28	855
Macomb	11	126	1,000	1,278	1,746	5,765	177	235
Manistee	11	114½	718	1,693	1,604	12,660	127	1,619
Marquette	11	97	217	238	801	6,568	10	745
Mason	11	101½	1,310	1,141	675	12,579	51	310
Mecosta	11	135½	790	202	558	4,791	69	1,929
Menominee	11	125	124	462	932	5,171	54	12
Midland	4	15½	168	184	190	406	28	408
Missaukee	11	181	1,220	466	937	9,728	135	1,408
Monroe	11	175	1,073	540	2,030	13,867	259	1,345
Montcalm	11	99½	879	895	2,413	3,509	45	521
Montmorency	3	45	58	48	210	1,408	30	834
Muskegon	11	105	629	1,345	582	920	19	280
Newaygo	11	106½	623	364	826	4,472	135	496
Oakland	10	124	1,020	995	1,299	3,859	29	1,021
Oceana	11	115½	818	476	1,602	8,658	143	373
Ontonagon	7	87	679	2,224	715	3,284	34	208
Osceola	10	108	560	1,161	1,084	6,472	38	2,677
Otsego	3	255	19	11	31	402	9	74
Otsego and Montmorency	7	82	108	40	187	454	27	98
Ottawa	11	111	353	538	1,653	9,045	19	1,302
Presque Isle	10	88½	197	321	409	6,599	27	540
Roscommon and Crawford	11	164½	302	542	959	1,470	79	901
Saginaw	11	119	523	927	800	1,600	22	1,030
St. Clair	11	138	2,318	1,878	1,713	4,620	88	4,425
St. Joseph	11	142	636	551	783	2,118	55	46
Schoolcraft	11	158	439	557	784	4,428	57	553
Shiawassee	8	585	655	747	703	583	78	4,314
Tuscola	11	94½	1,976	3,301	1,552	1,336	138	12,995
Van Buren	11	131	1,031	1,525	1,955	5,005	452	4,739
Washtenaw	11	180½	1,763	1,907	925	5,629	49	122
Wayne	11	104½	868	399	1,404	6,423	27	8,240
Wexford	11	154½	402	463	1,055	6,242	54	137
Totals	....	8,383	60,889	58,557	68,933	391,390	4,738	110,130

STATISTICAL SUMMARY—OFFICE—*Continued.*

ASSISTANT COUNTY AGENTS.

County.	Months reported.	Days in office.	Calls on agents.	Telephone calls	Letters written.	Copies of circular letters mailed.	Articles in local press.	Bulletins distributed.
Allegan	11	112½	325	275	325	675	....	363
Ottawa	11	120½	2	3	511	1,391	2	213
Van Buren	3	49	196	181	130	156	....	590
Totals	....	2,820	523	459	976	2,222	2	1,166

STATISTICAL SUMMARY—FIELD.

From July 1, 1918 to June 1, 1919.

County.	Months reported.	Days in field.	Farm visits.	Demonstrations. Started.	Demonstrations. Visited.	Demonstrations. Meetings.	Demonstrations. Attendance.	Other Meetings.	Attendance.
Alger	11	137	655	50	10	5	41	17	758
Allegan	11	176	303	35	20	29	536	80	4,928
Alpena	4	45	145	4	12	12	289	16	1,474
Antrim	11	163	268	5	5	8	151	92	6,124
Baraga	11	133	339	20	37	9	239	38	1,092
Barry	11	153½	635	23	4	7	3,142	69	4,180
Bay	11	50	176	....	2	....	....	18	675
Benzie	5	38½	121	10	1	1	10	59	1,765
Berrien	11	154½	427	17	3	23	433	126	6,526
Branch	11	153½	430	60	43	23	4,774	56	3,781
Calhoun	10	79	257	31	10	5	92	77	5,064
Cass	11	155	429	33	16	22	384	10	1,410
Charlevoix	10	110½	529	19	2	4	195	46	2,047
Cheboygan	11	135	386	8	4	32	733	67	2,872
Chippewa	11	155	523	21	48	2	405	27	669
Clare	2	14½	124	3	1	....	....	4	750
Clinton	11	118	159	9	10	2	13	73	2,987
Delta	11	146	398	....	20	16	53	33	1,188
Dickinson	11	156½	339	6	....	9	69	24	1,337
Eaton	10	82½	243	18	1	25	388	72	6,646
Emmet	11	186½	510	80	53	12	295	108	3,630
Genesee	11	143	463	35	....	30	963	44	1,968
Gladwin	11	81½	323	22	1	10	301	59	2,343
Gogebic	11	168	622	369	387	1	20	19	1,162
Grand Traverse	11	129	465	1	34	7	338	81	4,048
Houghton	5	116½	246	....	25	3	42	26	707
Ingham	9	52½	540	....	....	....	....	15	1,487
Iosco	11	75	348	47	39	5	44	65	3,740
Iron	11	149	263	91	38	75	130	56	1,549
Isabella	11	147½	377	25	26	7	334	32	863
Jackson	11	132	304	10	25	5	1,112	31	1,858
Kalamazoo	11	109½	248	6	....	31	220	76	3,714
Kalkaska	11	133½	437	....	5	10	149	80	5,100
Kent	11	113½	165	8	4	11	168	86	6,483
Lapeer	11	108	149	....	2	5	121	64	2,301
Leelanau	2	3½	....	....	....	....	....	1	32
Leelanau and Benzie	7	107	148	1	....	....	....	38	2,928
Lenawee	11	124	....	....	....	....	....	37	2,675
Livingston	6	101	343	104	56	....	....	11	845
Luce	10	111½	383	5	32	4	37	....	....
Macomb	11	151½	312	2	1	....	....	114	6,838
Manistee	11	148½	346	44	18	21	159	142	14,733
Marquette	11	174	385	30	23	9	60	40	1,614
Mason	11	167½	230	40	28	1	7	89	5,199
Mecosta	11	97½	195	1	18	....	....	75	3,572
Menominee	11	115	421	23	32	10	262	43	1,867
Midland	4	59½	186	8	13	8	198	....	....
Missaukee	11	90½	396	10	15	4	65	41	1,850
Monroe	11	103½	478	17	3	....	....	80	3,796
Montcalm	11	183½	609	115	62	12	380	65	4,529
Montmorency	3	32	94	32	5	1	55	24	689
Muskegon	11	146½	338	74	113	17	369	51	3,432
Newaygo	11	173½	623	115	154	12	140	51	7,916
Oakland	10	106	256	8	30	3	146	90	6,783
Oceana	11	156	272	20	46	38	574	56	4,018
Ontonagon	7	73	239	....	....	9	200	27	783
Osceola	10	110½	421	8	8	12	580	39	3,525
Otsego	3	7	20	2	....	....	....	5	120
Otsego and Montmorency	7	87	372	4	2	1	8	27	67[illegible]
Ottawa	11	161	268	22	27	25	745	122	6,38[illegible]
Presque Isle	10	151½	196	1	5	14	357	69	2,54[illegible]
Roscommon and Crawford	11	119½	270	43	30	9	72	45	2,4[illegible]
Saginaw	11	133	217	5	7	4	21	37	1,3[illegible]
St. Clair	11	144½	180	111	14	9	40	79	4,6[illegible]

STATISTICAL SUMMARY—FIELD—*Continued.*

County.	Months reported.	Days in field.	Farms visited.	Demonstrations.				Other meetings.	Attendance.
				Started.	Visited.	Meetings.	Attendance.		
St. Joseph	11	141	373	101	202	54	8,223	68	2,480
Schoolcraft	11	116	360	4	1	4	32	22	649
Shiawassee	8	99½	492	17	....	2	700	28	2,950
Tuscola	11	163	452	35	68	47	1,016	46	3,860
Van Buren	11	140	679	33	6	29	311	77	3,630
Washtenaw	11	895	362	3	....	12	165	35	2,916
Wayne	11	178	497	7	5	49	345	101	4,511
Wexford	11	113	80	4	1	....	....	46	1,644
Totals	....	83,234	23,840	2,115	1,913	798	31,451	3,783	215,618

ASSISTANT COUNTY AGENTS.

Allegan	....	158	343	24	35	30	633	48	2,396
Ottawa	....	124½	161	21	37	15	247	64	2,934
Van Buren	....	28	172	3	2	13	175	6	301
Totals	....	310½	676	48	74	58	1,055	118	5,631

STATISTICAL SUMMARY.

From July 1, 1918 to June 30, 1919.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
No. of Agents reporting	65	67	67	65	65	62
OFFICE.						
Days in office	690	145½	684	681½	761½	1,038½
Calls on agent:						
Personal	5,927	5,350	6,260	4,522	3,634	3,683
Telephone	7,276	5,982	6,871	5,192	4,167	4,589
Articles published in the local press	528	426	458	333	327	422
Letters written	7,426	6,306	6,715	5,742	4,522	6,313
Circular letters mailed	27,865	20,169	30,089	23,667	17,786	22,225
Bulletins distributed	15,257	8,478	11,680	3,537	4,210	4,428
FIELD.						
Days in field	1,145½	813½	1,216	747½	617	506½
Farm visits made	5,486	3,281	3,875	2,399	1,429	798
Demonstrations:						
a. *Started*	260	102	286	133	113	108
b. Visited	469	220	292	218	94	39
c. *Meetings held at*	267	56	85	59	41	48
d. Attendance at meetings	5,684	1,253	10,341	3,700	673	617
Other meetings held	347	278	335	140	147	244
Attendance	23,009	38,790	14,555	4,342	7,016	8,139

	Jan.	Feb.	Mar.	Apr.	May.	
No. of agents reporting	64	63	61	64	60	....
OFFICE.						
Days in office	902	845½	951	732½	557½	....
Calls on Agent:						
Personal	4,519	4,057	5,807	4,650	3,474	....
Telephone	4,524	4,067	6,054	5,500	4,353	....
Articles published in local press	565	363	523	413	380	....
Letters written	4,949	5,464	8,283	7,322	5,890	....
Circular letters mailed	25,080	21,570	37,356	38,160	26,941	....
Bulletins distributed	5,851	9,331	21,375	13,939	12,059	....
FIELD.						
Days in fie d	500	555	796	724	824½	....
Farm visits made	637	384	994	1,922	2,705	....
Demonstrations:						
a. Started	116	42	138	317	505	....
b. Visited	30	13	47	162	285	....
c. Meetings held at	14	15	35	79	47	....
d. *Attendance at meet.*	373	497	1,676	5,281	1,119	....
Other meetings held	384	499	664	398	374	....
Attendance	20,705	32,691	35,501	16,971	14,380	....

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Number Assistant agents reporting	3	3	3	2	2	2
OFFICE.						
Days in office	41½	32	32½	28	23½	32½
Calls on agents:						
Personal	90	103	90	10	23	35
Telephone	92	91	84	14	20	25
Letters written	123	109	105	119	75	96
Circular letters mailed	69	100	156	173	103	54
Bulletins distributed	155	112	447	....	10	....
FIELD.						
No. assistant agents reporting	3	3	3	2	2	2
Days in field	46½	33½	49	20	22½	18½
Farm visits made	221	100	82	71	40	17
Demonstrations:						
a. Started	7	2	3	....	5	1
b. Visited	16	5	33	5	5	....
c. Meetings held at	12	1	26	12	12	1
d. Attendance	283	25	350	95	240	7
Other meetings held	10	6	8	6	18	2
Attendance	326	592	256	205	419	75

STATISTICAL SUMMARY—*Continued.*

	Jan.	Feb.	Mar.	Apr.	May	
Number assistant agents reporting	2	2	2	2	2	....
OFFICE.						
Days in office	25½	20½	24½	19	12½	....
Calls on agents:						
Personal	33	41	38	30	30	....
Telephone	30	40	33	15	15	....
Articles published in local press	1	....	1	....	....	....
Letters written	55	36	118	79	51	....
Circular letters mailed	869	575	84	14	25	....
Bulletins distributed	94	....	139	200	....	....
No assistant agents reporting	2	2	2	2	2	....
FIELD.						
Days in field	19½	19½	32½	26½	22½	....
Farm visits made	6	19	36	48	42	....
Demonstrations:						
a. Started	1	....	7	17	5	....
b. Visited	....	....	2	4	4	....
c. Meetingd held at	....	....	....	3	1	....
d. Attendance at meetings	....	....	....	45	10	....
Other meetings held	15	11	22	10	10	....
Attendance	*741*	*827*	*1,130*	*535*	*625*	....

THIRTY-SECOND ANNUAL REPORT

OF THE

EXPERIMENT STATION

OF THE

Michigan Agricultural College

UNDER THE HATCH AND ADAMS ACTS

FOR THE

YEAR ENDING JUNE 30, 1919.

For members and organization of the State Board of Agriculture in charge of the Station and list of officers, see pages 5-11 of this volume.

REPORT OF SECRETARY AND TREASURER.

The following shows the receipts and disbursements of the Experiment Station for the year ending June 30, 1919.

		Dr.	Cr.
July 1, 1918.	To balance overdrawn.	....	$5,180 36
Aug. 16, 1918.	received from U. S. Treasury	$5,000 00	....
Oct. 3, 1918.	received from U. S. Treasury	2,500 00	
Nov. 4, 1918.	received from U. S. Treasury	7,500 00	
Jan. 23, 1919.	received from U. S. Treasury	7,500 00	
Apr. 18, 1919.	received from U. S. Treasury	7,500 00	
June 30, 1919.	license fees, commercial fertilizers	7,170 00	
	license fees, commercial feeding stuffs	14,975 00	
	farm and miscellaneous receipts	2,105 92	
	from State appropriation, South Haven Experiment Station	2,555 64	
	from State appropriation U. P. Experiment Station	19,805 00	
	from South Haven Experiment Station receipts	*530 81*	
	from U. P. Experiment Station receipts	7,653 04	
	from State Treasurer 1-5 Mill	30,000 00	
	By disbursements as per vouchers filed in the office of the State Auditor General	....	125,219 43
	balance overdrawn	15,604 38	
Total		$130,399 79	$130,399 79

Fifty thousand regular bulletins No. 282; fifty thousand regular bulletins No. 284; twenty-five thousand regular bulletins No. 283; seven thousand five hundred special bulletins No. 90; seven thousand five hundred special bulletins No. 91; six thousand five hundred special bulletins, No. 92; twenty-five thousand special bulletins No. 93; twenty thousand special bulletins No. 94 twenty thousand special bulletins No. 95; five thousand five hundred special bulletins No. 96; twenty-five thousand special bulletins No. 97; ten thousand circular bulletins No. 36; seven thousand five hundred circular bulletins No. 37; seven thousand five hundred circular bulletins No. 38; three thousand circular bulletins No. 39; three thousand circular bulletins No. 40; four thousand five hundred technical bulletins No. 43; fifty thousand quartly bulletins Vol. 1, No. 1: three thousand five hundred technical bulletins No. 44; fifty thousand quarterly bulletins Vol. 1, No. 2; fifty thousand quarterly bulletins Vol. 1, No. 3; fifty thousand quarterly bulletins Vol. 1, No. 4; one thousand press bulletins No. 63; one thousand press bulletins No. 64; have been issued by the Experiment Station during the fiscal year.

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.

	Hatch fund.	Adams fund.
Salaries:		
Director and other administrative officers	$1,619 60	....
Scientific Staff	2,574 80	$2,746 90
Assistants to scientific staff	7,279 25	9,290 85
Labor:		
Annual and monthly employees	226 60	630 00
Balance by week, day and hour as needed	989 47	923 12
Publications:		
Other expenses (copper half-tones)	119 81	....
Postage and stationery:		
Postage	126 40	....
Stationery	18 44	2 80
Telegraph and telephone	25	....
Freight and express	5 00	37 88
Heat, light, water and power:		
Heat	147 15	....
Chemicals and laboratory supplies:		
Chemicals	54 52	....
Other supplies	147 64	35 49
Seeds, plants, and sundry supplies:		
Horticultural	10 80	....
Botonical	37 20	....
Entomological	24 34	....
Bacteriological	9 42	39 89
Soils	42 32	....
Farm Crops	138 04	....
Fertilizers	45 00	3 00
Feeding Stuffs	....	682 19
Library:		
Four volumes American Journal of Physiology	20 20	....
One volume Journal of the society of Chemical Industry	12 50	....
One volume Soil Science	7 00	....
Binding sixty-five volumes	74 75	....
Binding forty volumes	46 00	....
Binding one hundred twenty-three volumes	141 45	....
Other items	235 90	....
Tools machinery and appliances:		
(a) *New purchases*	166 34	18 82
(b) Repairs	15 28	70
Items of principal purchase: Hatch. / Adams.		
One 1½ H. P. 220 V. Shunt Wound motor — Hatch $101 63		
One fourteen inch Stillson wrench — Hatch 1 75		
One food grinder — Hatch 1 98		
One set sargent bits — Hatch 6 50		
One B. and V. brace — Hatch 3 50		
One tank heater — Adams $8 00		
One silage cart — Adams 4 90		
Furniture and fixtures:		
One lamp	....	90
One nitrogen lamp	90	....
Miscellaneous	....	1 00
Scientific apparatus and specimens:		
One bacteria grinder with pulley and handle	....	36 10
Three maximum registering thermometers	11 29	....
Live Stock:		
Small experimental animals	....	56 50
Traveling expenses:		
In supervision of station work	54 28	....
In connection with investigations under the Adams Act	....	6 65
For other purposes connected with station work	578 06	....
Contingent expenses:		
One year's dues, 1918-1919, *Association of American Colleges and Experiment Stations*	20 00	....
Buildings and land:		
New buildings	....	487 21

DISBURSEMENTS OF EXPERIMENT STATION MONEYS—OTHER THAN RECEIVED FROM U. S. TREASURER

Salaries	$35,603 92
Labor	18,561 55
Publication	439 15
Postage and stationery	988 77
Freight and express	554 73
Chemicals and laboratory supplies	3,249 95
Seeds, plants and sundry supplies	5,142 97
Fertilizers	1,266 58
Feeding stuffs	6,822 30
Library	103 29
Tools, machinery and appliances	2,355 48
Furniture and fixtures	692 90
Scientific apparatus and specimens	1,237 00
Live Stock	770 70
Traveling expenses	5,558 78
Heat, light and water	98 40
Building and land	11,772 94
Balance overdrawn	15,604 38
Total	$110,823 81

REPORT OF DIRECTOR OF EXPERIMENT STATION.

To President F. S. Kedzie:

During the past year the work of the Experiment Station was seriously interfered with on account of the loss of so many workers to serve in the army and navy or to aid indirectly in a variety of activities having some bearing on war service. It was necessary to abandon some of the investigational projects temporarily, particularly those having the most intricate scientific bearings with least prospect of producing immediate results to be used in agricultural practice. At this time many of these suspended investigations have been taken up with the prospect that all will be resumed in the near future. The war conditions calling for increased agricultural production resulted in a greatly increased demand on the Station for a great variety of assistance to furnish speedy relief as the increased emergencies arose.

The administration of the funds of the Station was beset with difficulties this year. At the beginning of the year the Station funds were fully apportioned to defray salaries and operating expenses. At this time a number of our Station workers were on leaves of absence granted by the State Board of Agriculture for the duration of the war. After the signing of the armistice in November, 1918, many of our men returned to occupy their former positions. In addition several temporary appointments were necessary to meet the demands made upon the Station. This situation required the appropriation of more money than was made available during the year.

The following statement includes the funds disbursed during the year, indicating their source:

Hatch Funds	$ 15,000.00
Adams Funds	15,000.00
State Funds	63,282.67
Upper Peninsula Station Funds	28,835.59
South Haven Station Funds	3,101.17
Total	$125,219.43

A report of the work of the Upper Peninsula Station at Chatham, appears elsewhere. Mr. B. W. Housholder, after three years of very satisfactory service, was succeeded by D. L. McMillan, April 1, 1919.

The following list comprises all bulletins issued by the station during the year:

Regular:

282—Sept. 1918. Commercial Feeding Stuffs, 45,000. A. J. Patten C. F. Barnum, E. F. Berger, T. E. Friedemann, P. O'Meara.

283—Dec. 1918. Fertilizer Analyses, 25,000. A. J. Patten.

284—Jan. 1919. Some Information and Suggestions Concerning the Use of Phosphorus, 50,000. M. M. McCool, C. E. Millar, G. M. Granthum.

Special:

90—Nov. 1918. Special Report of the Upper Peninsula Experiment Station, 7,500. B. W. Housholder.

91—Nov. 1918. Some General Information on Lime and its Uses and Functions in Soils, 7,500. M. M. McCool, C. E. Millar.
92—Dec. 1918. Feeding Value of Skim Milk, 6,500. H. W. Norton, Jr.
93—Feb. 1919. Spray and Practice Outline for Fruit Growers, 25,000. H. J. Eustace, R. H. Pettit.
94—Feb. 1919. Financial History of a Twelve Year Old Peach Orchard, 20,000. H. J. Eustace, F. M. Barden.
95—Feb. 1919. Musk Melon Culture in Michigan, 20,000. C. W. Waid.
96—May 1919. Analyses of Insecticides and Fungicides, 5,500. A. J. Patten, E. F. Berger.
97—June 1919. Alfalfa in Michigan, 25,000. J. F. Cox.

Circulars:
36—Feb. 1919. Planting the Rural School Grounds, 10,000. C. P. Halligan.
37—Mar. 1919. Raspberry Culture, 7,500. R. E. Loree.
38—Mar. 1919. The Culture of Currants and Gooseberries, 7,500. R. E. Loree.
39—May 1919. Foul Brood, 3,000. B. F. Kindig.
40—June 1919. Infectious Abortion and Sterility in Cattle, 3,000. E. T. Hallman.

Technical:
43—Nov. 1918. Soluble Salt Contents of Soils and Some Factors Affecting it, 4,500. M. M. McCool, C. E. Millar.
44—Nov. 1918. Rate and Extent of Solubility of Soils Under Different Treatments and Conditions, 3,500. G. J. Bouyoucos.

Press:
63—Oct. 1918. House Flies and Influenza. W. L. Chandler.
64—May 1919. Onion Maggot, 1,200. R. H. Pettit.

Four copies of the Experiment Station Quarterly have appeared during the year. This publication is intended to convey to those whose names are included on the entire mailing list, a variety of useful information relating to agricultural practice and resulting either directly or indirectly from Station investigational work. This publication seemed to be very acceptable to our readers and especially useful to County Agents and other Extension workers.

It is still our earnest desire to organize investigational work in farm management and rural economics. This would stimulate and greatly aid both educational and Extension work along these lines. In the same manner investigational work in farm mechanics is needed as a basis upon which to upbuild other lines of effort.

The Station organization greatly appreciates the prospects of larger financial support, now that the general revenues of the institution have been increased. This will enable us to more fully meet the needs of those seeking help.

Respectfully submitted,
R. S. SHAW,
Director.

East Lansing, June 30, 1919.

REPORT OF THE BACTERIOLOGICAL SECTION

Director R. S. Shaw:

Dear Sir—With the signing of the peace treaty almost synchronous with the rendering of this report it is with regret that we are unable to report that the work of this division is on a peace or pre-war basis. You were made acquainted by our last report with the losses that we had suffered in our experimental staff up to July 1st. In the fall of 1918, assistant bacteriologist, F. W. Fabian, entered the sanitary corps of the army as a lieutenant.

However, to counteract our losses we had the excellent assistance of Dr. E. T. Hallman of the Department of Animal Pathology who maintained intact the experimental herd for the infectious abortion investigations and materially added to our fund of information on the nature of the disease. Assisting in this work was Dr. D. J. Lamoureaux who labored faithfully until a brilliant career in the field of research was cut short by his untimely death from influenza, February 27, 1919.

Lieutenant S. N. Lord of the Canadian Expeditionary Force was with us from July until December 1918, but on account of a heavy teaching schedule and the confusion resulting from the influenza epidemic, he was unable to accomplish anything with the problem formerly in charge of Mr. Cooledge. Mr. Fabian, Mr. Nobles, and Dr. Stafseth returned early this year and Mr. Cooledge in May. Mr. Morgan and Mr. Huddleson are still with the A. E. F.

We have, therefore, been unable to make any progress along some lines and very little advancement along others throughout most of the year and even yet some of our projects must remain untouched. The situation is briefly as follows:

Adams 1a. The effect of diseases in the cow on the milk. Nothing was accomplished until the return of Mr. Cooledge who is planning and pursuing his work now with vigor.

Adams 1b. The keeping qualities of butter. Mr. Ruehle has been working throughout the year at the problem but his progress has been impeded by the unsatisfactory manner in which he found the records of previous investigations, by a heavy teaching schedule and a number of diversions that, ordinarily, would have fallen to the lot of Mr. Cooledge. A record of his work appears herein later.

Adams 2c. Soil solution and its rôle in the life of soil microbes. This project has been effected the least seriously of any of our projects. As a matter of fact we feel that much has been accomplished by Miss Northrup in her studies on the decomposition of peat as will be seen from her report which follows.

Adams 3a. Swine epizootics. No work has been done on this project for two years past and none is planned for the immediate future due to absence of the available man in the army.

Adams 3b. Bovine infectious abortion. Dr. Hallman, Dr. Lamoureaux and, for the past few months, Dr. Stafseth have made progress in their investigations. I refer you to Dr. Stafseth's report.

Mr. Cooledge reports as follows:

"Having just returned from leave of absence on military service, I have no report to make upon progress of experimental work during the past year.

"While in service I was stationed at Rimecourt, Haute Marne, France in the laboratory of Base Hospital 52. I was in the army between the dates February 4, 1918 and May 15, 1919.

"I am continuing my studies upon the general problem (Adams 1a) Relation of diseases of the cow to the milk, and have under way or projected the following phases of the problem as applied to infectious abortion.

"I. Study of the possibility of the udder, through the teats, being an avenue of entrance for *Bact. abortus.*

"II. Attempt to improve methods for studying the presence of *Bact. abortus* in the udder.

"III. Feeding experiments with *Bact. abortus* infected milk.

"IV. Nature of *Bact. abortus* infection in the udder. A bacteriological and pathological study of *Bact. abortus* infected udders to be taken up in cooperation with the Department of Pathology.

"V. Study of strains of *Bact. abortus* and abortus-like organisms isolated from milk."

Mr. Ruehle has the following report:

"The research work on butter has been on the Adams Fund Project 1b entitled, 'The Keeping Qualities of Butter.' This work is still in progress but has not progressed to the point where publication would be desirable. A preliminary report of one phase of the work has been embodied in a paper entitled, 'A Microscopic Method of Examining Butter for Microorganisms'. This was read before the Section on Sanitary and Medical Sciences of the Michigan Academy of Science, on April 3, 1919. An abstract of the paper follows this report.

"In examining a substance for the presence of microorganisms, it is always desirable to be able to analyze the material microscopically as well as culturally. In preliminary examinations of the butter by the microscope it was found that a large proportion of the bacteria are imbedded in particles of casein. This would indicate that any cultural method of counting the microorganisms in butter would give counts much below the actual number present in the butter.

"After some experimentation the following technique was adopted and is still being studied:

"One gram of butter was weighed out and transferred to a clean separatory funnel. One cubic centimeter of hot water was added to the butter and the whole mass agitated until the butter was melted and thoroughly mixed with the water. Then 50 c.c. to 100 c.c. of ether, gasoline, or other fat solvent was added to dissolve the fat, when it was allowed to stand until the two liquids had separated. The aqueous portion was drawn off into a graduated cylinder and an equal amount of sterile skim milk, which had been allowed to sediment for a week or more after sterilization, was added to the aqueous extract of the butter. After mixing 0.02 c.c. of the mixture was spread out with a needle on a glass slide so that it covered an area of 1 square centimeter. Sometimes a larger amount of butter was used but in those cases a larger amount of warm water was used so that in every case 0.02 c.c. of the final mixture represented approximately 0.01 gram of the butter. The smears were then treated in the same manner as the milk smears are treated in the Breed method of counting bacteria in milk; namely, the smears were dried quickly on a warm plate, immersed in xylol for a minute to dissolve any trace of fat, fixed for one minute in alcohol, stained with a one per

cent aqueous methylene blue solution, destained to a light blue color in alcohol and dried. Duplicate smears were always made for each sample. The counting was done under a compound microscope in the same manner as in the Breed method. In this work an E. Leitz 1-12 oil immersion objective was used with a No. 1 ocular and the draw tube adjusted to 152 mm. There was also used a special ocular micrometer marked into quadrants with cross-hairs and a circle 8 mm. in diameter. This combination gives a factor of 650,000 for every bacterium seen in one field. From 10 to 40 fields were counted and averaged per sample. The following results were secured (see table):

Butter Sample No.	Kind of Cream.	Plate Counts.	Microscopic Count.	
			Groups.	Individuals.
1	Pasteurized, ripened by starter	620,000	5,035,000	7,962,500
2	Pasteurized, ripened naturally	168,000	9,250,000	14,925,000
3	*Pasteurized, ripened naturally*	*101,000*	*666,250*	*980,000*
4	Pasteurized, ripened by starter	5,000,000	9,600,000	14,880,000
5	Pasteurized, ripened by starter	1,240,000	25,350,006	40,950,000
6	Raw-ripened naturally	16,600,000	10,010,000	17,680,000
8	Unknown	3,165,000	3,022,750	5,590,000
9	Raw-ripened naturally	9,100,000	5,622,500	8,582,500
10	Unknown, dairy butter	3,597,000	2,782,500	4,290,000
	Torulae	....	325,000	325,000

"In every case when the cream was first pasteurized the results by the microscopic group count were higher than by the plating method, which is not surprising since the dead cells would stain as well as the living ones. But where raw cream was used the results by the plating method are higher than the microscopic group count. This is opposed to all experience with the microscopic technique when applied to milk, where one usually gets results from 2 to 5 times as large with the microscope as with the petri plate. The reason for this is not clear though our experience with sample No. 10 suggests a partial explanation. Representative colonies on the plates were fished, grown in milk, and stained. It was found that the bacteria took the stain very poorly. Various stains were tried but with little better success except with Giemsa's stain which differentiated the bacteria and the casein of the milk very well, when the culture was grown in milk. But when this stain was applied to the butter smears it did not stain the bacteria more successfully than other stains. Another possible cause for overlooking bacteria in counting the smears is the small size of the usual flora of butter, which consists principally of *Bacterium lactis acidi*. Neither of these suggestions seems to fully explain the discrepant results and further search is being made for the reason. In two of the experiments the non-aqueous portion was examined for bacteria but none were found. It is realized that the foregoing discussion is based on very few data. The main reason for presenting it at the present time is in the hope that some suggestion may be received that will help to solve the difficulties encountered."

Miss Northrup reports on her Adams project in the following words:

"Succeeding the entrance of 1st Lieut. J. F. Morgan into the Medical department of the army, I was placed in charge of the soil work including experiments already started. After a year's work, I am able to give the following report of progress.

"In the experiment already under way when the problem was turned over to me in the spring of 1918 a series of composts consisting of various proportions of peat and manure had been made, viz., 50-50; 75-25; and 90-10 peat and manure respectively including a pile each of peat alone and manure alone. These were used on an experimental plot consisting of nearly pure sand and sowed with Canada field peas. It was soon noted that the plots containing pure (100 per cent) peat first, then in succession the mixtures containing the lesser percentages of peat showed the most rapid growth, in marked contrast not only to the check (sand) as would be expected but to the manure alone. This phenomenon is attributable to nothing else but to the water holding capacity of the peat. Later experiments have shown this same sequence of events on another type of soil with another crop.

"Bacteriological studies were made of the sandy soil alone and with the different additions during the growing period.

"The peas were picked and used in a canning experiment. Studies of the soil solution from these piles showed a larger percentage of nitrates per unit amount of manure in the pile containing the least amount of manure.

"The concrete compost pit which was described in the 1918 Annual Report was completed in July, 1918, and filled with a mixture of peat, manure, and rock phosphate with the addition of sufficient liquid manure to insure anaerobic conditions as well as to serve as an inoculum. Bacteriological and chemical analyses have been made from samples taken bi-weekly as a rule except through the winter months.

"Bacteriological analyses show that large numbers both of aerobic and anaerobic cellulose decomposing organisms were present and are on the increase. In the aerobic class, which includes not only bacteria but actinomycetes and molds the average number now (June 1919) approximates 3,000,000 per gram of oven-dry mixtures. The anaerobic class also approaches this figure, having increased to this amount from an average of about 5,000 per gram of oven-dry mixture. Thus it would seem that the cellulose portion of the peat must be undergoing decomposition and that the conditions in this pit are not inimical to organisms of this class.

"Work with the organisms concerned in the dissolution of rock phosphate shows their presence quite frequently in considerable numbers, but at present the known cultural methods are faulty. This is one general drawback to rapid progress along certain lines of soil bacteriological work. Chemical analyses of the material from the pit show that there has been roughly an increase of about 8 per cent in the citrate-soluble phosporus in a period of nine months. There has been a decrease in total phosphorus of about 20 per cent of the original amount present. This can be accounted for by the presence of large amounts of citrate-soluble phosphorus in the drainage water. If this also is taken into consideration considerably more than 8 per cent of the citrate-soluble phosphorus has been liberated in the past nine months.

"As the presence and number of Azotobacter species in soil can be determined quite readily by the mannit agar plate method it has been possible to enumerate them in this compost with considerable accuracy Azotobacter have been found not only in the surface samples but in the bottom samples, which have existed for over 9 months under decidedly anaerobic conditions.

"Other bacteriological tests have been made whose significance is not apparent as yet. However, several interesting phenomena have occurred which will bear further investigation. It has been found that many species of actinomycetes have the power of digesting cellulose aerobically and under partial anaerobic conditions also. Assuming that the cellulose of peat can be attacked by this group of organisms, this may account for the great increase in numbers, at least proportionately, of the actinomycetes in the different depths of the compost pit.

"Nothing so far indicates that the nitrogen of the peat has been attacked to any extent.

"At this time (June 1919) the contents of the concrete compost pit are being removed and placed under more aerobic conditions in four bins eight feet square by three feet high, each bin representing a layer from the pit of about two feet deep. Studies of the contents of these bins are to be continued to ascertain the change in rate of the microbial decomposition, and consequently in the type of microbial flora and the changes they bring about. The pit is then to be filled with a similar mixture, employing some of the mixture taken out, as the inoculum in place of manure. Studies both bacteriological and chemical are to be made of this mixture."

Dr. Strafseth makes the following report:

"The research work on bovine infectious abortion has not progressed very rapidly since Mr. I. F. Huddleson enlisted in the army. Shortly after the outbreak of the war seven members of this department entered the service. This, of course, left the department facing a very difficult situation. No one was left to take charge of the problem and to secure suitable assistants was almost impossible, as every young man was subject to military duty. Through the kind aid of Dr. E. T. Hallman of the Department of Animal Pathology and Dr. D. J. Lamoureaux, his assistant, the maintenance of the experimental herd was made possible. Various projects were outlined and the work was progressing smoothly, when Dr. Lamoureaux was taken away after a short illness of pneumonia. This happened about two weeks after my return from the army. Dr. Lamoureaux had just started to compile his data and I had not yet become familiar with his work at the time of his death, so I am unable to render any report on the results which he obtained. From his outlines, I judge that his work was mainly along the same lines as that which I have planned for next year. Records of the breeding and blood reactions of the animals in our experimental herd were kept which will be of great value to us in the future.

"Our herd now consists of ten cows, eleven heifers, six calves and two bulls.

"The work outlined for next year is as follows:

1. Determination of the avenue of entrance of the *Bact. abortus.*
2. Persistence and localization of same in the animal body.
3. Mode of dissemination.
4. Study of concomitant infections to determine their relation to infectious abortion and sterility.
5. Immunization by means of lipo-vaccines.
6. Finding the better methods for the isolation and cultivation of the *Bact. abortus.*

"Since my return from the army I have devoted about one-third of my time to teaching. Besides that, we have been short of help and the research work has, therefore, progressed very slowly, but we hope to do better as soon as conditions return to a normal basis.

"Some experiments have been carried out to see if the *Bact. abortus* will penetrate into the deeper layers of the uterine mucosa and remain in localized areas as a latent infection. Our results seem to indicate that staphylococci, streptococci and the *B. coli communior* may do this, but we have not found abortion bacilli in any of the cases, which we have examined. Material for such work is scarce, so we have not yet been able to examine a sufficient number of genital organs to give us any conclusive data on this subject.

"The problem of isolation and cultivation has been worked on with some promising results. One of the workers of the Department of Animal Pathology of the Rockefeller Institute for medical research has described an improved method of isolating the *Bact. abortus* from macerated fetal membranes of aborting cows. This method consists in injecting guinea pigs intraperitoneally or subcutaneously with high dilutions of the suspected material and then allowing one month to elapse before making the autopsy. At the end of this period the animals are killed and a piece of the spleen, about the size of a pea, is cut out and rubbed against an agar slant and then pushed down into the water of condensation. The tubes are now sealed with sealing wax and incubated for about ten days.

"We have tried this method with cultures of *Bact. abortus* and known infected milk as well as with milk and tissues from animals which have a history and blood reaction indicating that they are free from abortion disease. It is too early to give a detailed report, but we have found the characteristic lesions and obtained cultures of the *Bact. abortus* in those cases where infected material and pure cultures were used as inoculum, whereas the other cases proved negative. Instead of sealing the individual tubes, we place them in Novy jars and exhaust the air by means of a suction pump. Under such conditions we have obtained good growth in five days.

"Dr. Stanley G. Bandeen, graduate student in the departments of pathology and bacteriology, has been working on 'The relation of the bacterial flora of the uterus to that of the meconium of the calf.' The summary of his thesis reads as follows:

"The twenty-four cases (Table II) studied for a comparison of the flora of the uterus and meconium showed that the twelve uteri gave cultures in 83⅓ per cent. The uterus contained more organisms than the meconium. The meconium was found to be infected with *B. coli communior*, staphylococcus and streptococcus. These organisms were also found in the uterus. *Bact. abortus* was found to persist in the uterus for twenty eight days. In no case was *Bact. abortus* found in the meconium. In all cases except Case 805A whenever the meconium was infected, the uterus was found to harbor the same organism. In some cases the meconium was found to be sterile, while the uterus harbored organisms. *B. coli* and certain cocci were found in the sealed uteri of apparently normal cows. The results obtained in this article will be of interest to investigators, of white scours of calves, who believe that the calf is infected before birth. A large percentage of calves are born with infected meconium. The uterus is first infected, probably followed by the fluids and lastly, the

meconium. *The infection probably reaches the uterus by passing through* the cervix from the vagina before the seal is formed and persisting there throughout pregnancy.

"During the fiscal year ending June 30, 1919, 145 blood samples have been sent to this laboratory to be tested for *Bact. abortus* anti-bodies. The following shows the reactions obtained by the complement-fixation test: 96 samples were negative; 41 were positive; 5 gave a partial reaction; and 3 were not fit to be tested due to decomposition.

"Besides the work on abortion a number of specimens have been received from various parts of the State for bacteriological examination. There are no records showing what was done in that line prior to my return from the army.

"Since February 10, 1919, 19 specimens have been examined. The following gives the results of the examinations:

Hemorrhagic septicemia	5 cases
Pyemic infection	3 cases
Tuberculosis	1 case
Actinomycosis	1 case
Infectious mastitis	1 case

"Two specimens were tumors and were turned over to Dr. Hallman for diagnosis.

"The six remaining specimens were of such a nature that no diagnosis could be made."

Aside from our efforts to maintain the pure research problems supported by the Adams funds, it has not been possible to accomplish much along investigational lines except to give proper attention to routine matters and satisfy the demands made upon us by our correspondents.

Miss Northrup has been able to continue her studies into the nature of food decompositions. She has the following report to make on the work done by herself and under her direction:

"Report on Studies of Spoiled Human and Stock Foods for the Fiscal Year.

"A quart can of spoiling corn was brought into the laboratory to ascertain if possible the cause of the peculiar type of spoilage. The corn in the can appeared to the eye to be undergoing a sort of cellulose decomposition. There was no unpleasant odor and the taste was but little if any different from that of a good product. The consistency was very different, however; the kernels felt rather slimy, the inside portion slipped out of the seed coat like a grape out of its skin and felt smooth to the tongue. On standing gas production was noticed. No bacteria were observed in hanging drop. Cultures were made in various media but good growth was observed only on starch agar and anaerobically in tubes of sterile corn. An organism was isolated from starch agar and the following morphological and cultural determinations made.

Morphology: Short rods in pairs or short chains often appearing like a streptococcus, single only occasionally.

Starch agar slant: 24 hr. very fine, nearly translucent, pale white, round colonies; moderate spreading growth. 12 da., very fine beaded growth; no starch was decomposed.

Dextrose agar slant: Round, white individual colonies, larger than on starch agar; growth moderate to abundant. 12 da., very fine beaded growth resembling streptococcus colonies, somewhat opalescent, growth practically covering the slant.

Congo red agar slant: 24 hr., no noticeable growth. 12 da., scarcely visible growth along needle tract.

Litmus lactose bile agar slant: 24 hr. growth doubtful if any. 12 da., less growth than on Congo red agar.

Pork Dextrose broth: 0.5; 24 hr. no growth. 12 da., no growth.

Potato slant: 24 hr. doubtful if any growth. 12 da., moist growth along path of needle, colorless.

Corn agar slant: 24 hr. growth spreading and abundant. Small white dots in the abundant growth seem to be typical of this organism, these colonies being confluent and not distinct. Growth pale white and nearly translucent. Condensation water is cloudy, white. 12 da., abundant growth, translucent, marmorated, slightly opalescent, moist, considerable sediment at bottom of condensation water.

Lactose broth fermentation tube: 24 hr. no noticeable growth.

Dextrose broth fermentation tube: 24 hr., no noticeable growth. 12 da., reinoculated, no growth.

Saccharose broth fermentation tube: 24 hr. no noticeable growth. 12 da., a macaroni-like growth in the long arm and dense growth in bulb.

Sour whey agar slant: 24 hr., growth slight if any. 12 da., growth at base of slant scarcely visible.

Litmus milk: 24 hr., reduction at surface. 12 da., quite strongly acid not curded.

Dunham's solution: 24 hr., no growth, 12 da., sediment which comes up with a swirl, no clouding.

Nitrate peptone solution: 24 hr., no growth. 12 da., no growth.

Esculin bile solution: 24 hr., no growth. 12 da., no growth.

Corn tube: 24 hr., gas formation in bottom of tube. 12 da., gas formation very pronounced.

Peas (tube) anaerobic (oil): 24 hr., gas formation abundant and continues vigorously.

String bean tube, anaerobic (oil): 24 hr., clouding of liquid in tube, small amount of gas.

Dextrose gelatin agar. slant—0.5: 24 hr., growth like streptococcus. 12 da., colonies much smaller than on ordinary dextrose agar; a small amount of sediment in condensation water.

Gelatin stab: 24 hr., no growth. 12 da., no growth.

"This bacillus is an example of the type of organisms very frequently found in spoiling canned foods, i. e. an organism difficult to isolate on account of its peculiar cultural requirements. This organism grows well on no medium used except corn agar and sterile corn and peas. This peculiarity of certain organisms is very frequently the explanation why certain spoiled canned foods are declared sterile or the organisms isolated do not show gas production in ordinary media."

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"A sample of sausage which had been feeding experiments indicated that it was not poisonous at the time and contained no toxin-producing organisms."

"A sample of cottage cheese to which was attributed the serious illness of several people was examined for *B. botulinus;* also feeding experiments were performed with it. The animals fed did not become sick, but after considerable difficulty and delay an organism resembling *B. botulinus* morphologically and culturally was isolated from the cheese. Its toxin production has not been determined.

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"March 22, 1918, five cultures of *B. botulinus* were added to No. 2, cans of asparagus, string beans, beets, carrots, corn, peas, and tomatoes which were then sealed and heated in the hot water bath for the time prescribed for processing each product in the U. S. Dept. of Agriculture recipes. In July 1918, these were opened, shake cultures were made of each into gelatin agar and resealed but not reheated. These cultures were examined from time to time for evidences of growth and presence of *B. botulinus.* In only 5 out of the total of 31 cans inoculated was growth absent. *B. botulinus* was not observed in the culture from any can. Seven months after the cans were opened (11 months after they were inoculated and heated) five cans showed evidences of either a swell, leak, or swell and leak combined, three of peas, and one each of carrots, and beets. Microscopic examination of the juice from these cans showed a few very poorly staining rods in the beets, long-chained streptococci and a few rods in the carrots, cocci in one can of peas, rods in the other two. In one can of peas these rods contained polar spores resembling *B. botulinus* very closely. Subcultures from each can into a medium favoring *B. botulinus* showed nothing with four of the cans. The remaining one which proved to be the one typical microscopically was found to contain *B. botulinus* in a living condition.

"An article by Bovie and Bronfenbrenner* contains a graph which explains why resistant spore-forming organisms survive the processing in canning. The middle of the can contents reaches the maximum temperature but for a few minutes.

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"Miss Ruth Normington, a graduate student assistant in this department has been working largely under my direction this past year and has just completed a most satisfactory master's thesis entitled, 'Studies in the Heat Resistant Organisms of Cold Packed Canned Peas'. This will be published in the near future.

"The Journal of Bacteriology is publishing an article by myself and Ruth Normington entitled, 'The influence of Various Chemical and Physical Agencies upon *Bacillus botulinus* and its spores. I. Resistance to Salt.'

"At the 1919 meeting of the Michigan Academy of Science an article was read entitled 'The Relation of *B. botulinus* to certain phases of home economics and agriculture'. This will be published in the annual report of this society.

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"Eleven samples of silage, one of hay and one of dry stock food which had caused forage poisoning in live stock were sent to this laboratory for analysis. Six samples of silage representing silage from all but one source

*W. T. Bovie and J. Bronfenbrener, Studies on Canning. An Apparatus for Measuring the Rate of Heat Penetration. Jour. Ind. & Eng. Chem. Vol. 11, No. 6, June 1919, pp. 568-570.

contained an organism resembling *B. botulinus* morphologically and culturally, and the toxin from the culture isolated from one of these samples of silage resulted in the death of the experimental animals used. The toxin producing power of the other cultures has not definitely been determined. The sample of hay also contained organisms of this type, while those isolated from the dry feed were doubtful.

"The fact that so many samples of questionable silage were sent in for analysis seems to suggest that forage poisoning from this source is more common than has been heretofore supposed. The findings at this experiment station in so far as they go, correspond very closely to those obtained in the Kentucky and Illinois Experiment Stations. Indications are that forage poisoning is fairly common in this state. Because of this fact its more thorough study at this Experiment Station should not be disregarded, now that the 'ice is broken' by the other Stations named and work in a small way has been done here. This is a type of research requiring a very considerable amount of time, which has not been available this past year.

"Cultures of *B. botulinus* are continually being sent out to various laboratories and experiment stations for use in research on the various problems mentioned in this report.

"It is suggested that Michigan be second only to California in supporting an organization resembling her 'Botulism Research of the State Council of Defense.' "

REPORT OF VINEGAR INVESTIGATIONS.

"After the resignation of Mr. C. W. Brown December 1917, the vinegar studies were turned over to me but as instructional duties occupied practically all of my time, during the winter and spring terms, these studies were not continued until summer (1918). At this time, analyses were made of 28 barrels of cider which had been made by the Horticulture Department in the fall of 1917 and placed in cold storage. Eleven of these which had been removed later to the Bacteriological Department barn, were analyzed by Mr. Brown, October 19, 1917, with the following results:

Bbl. No.	Percent acid as acetic.	Percent alcohol by wt.
1	0.4	3.76
2	0.45	3.33
3	0.45	3.29
4	0.45	4.12
5	2.9	2.67
6	0.45	4.36
7	0.6	5.65
8	1.1	6.05
9	0.55	5.49
10	0.40	4.48
11	0.55	4.60

"Sugar was present in all samples. Barrels 1, 2 and 3 were marked with a negative sign, which means that there was so low a percentage of alcohol and sugar left that market standard vinegar (4 per cent acetic acid), could not be made. Barrels 4, 5, 6, 10 and 11 were marked with a question mark signifying that although there is actually enough alcohol present to make market standard vinegar, the margin is so low as to make the ultimate results doubtful.

"Barrels 7, 8 and 9 were passed as fully capable of forming sufficient acidity. The remaining barrels were removed from cold storage to the barn in July 1918. Analyses of certain of these and of the former barrels o llows:

Date, 1918.	Barrel	Per cent acetic acid.	Per cent alcohol by weight.	Sugar.	Date 1918.	Acid.	Alcohol.	Date inoculated Bact. aceti, 1918.	Date, 1918.	Acidity	Date.	Ac'd.	Alcohol.	Sugar.
9-30....	1	0.8			11-27	1.3					1-31-19	empty		
7-26....	3	0.7	2.5	–	9-30	0.8			11-27	2.0	1-31-19	1.4		
8-5.....	3	1.6	2.18											
8-21....	7	1.1	22.91*	–	9-30	1.7								
7-24....	10	0.6	5.03	–	11-27	1.5					1-31-19	3.2		
7-19....	*11*	*1.3*	*10.17*		*8-22*	*0.9*	*5.95*		*9-30*					
7-24....	12	3.8	0.75	+ +	9-30	4.9			11-27	8.7	*1-31-18* 5-20-19	8.3 8.0		 +
7-26....	13	0.7	0.32	–	9-30	0.8	–		11-27	1.8	1-31-18 *5-20-19*	1.5 *0.6*	 *1.09*	 –
7-26....	14	1.7	0.67	+ + +	9-30	1.7								
8-22....	*15*	*0.8*	*3.58*		*9-30*	*0.7*			*11-27*	1.6	1-31-18 *5-20-19*	1.4 0.8	 3.48	 –
7-24....	16	2.1	1.59	–	9-30	2.9				4.4	1-31-18 5-20-19	6.2 7.5	 2.47	 +
7-26....	*17*	*0.6*	*4.5*	–										
8-5.....	18	0.9	3.26	–	9-30	1.8		9-3	11-27	3.6	1-31-18 5-20-19	2.2 1.4	 4.02	 –
8-7.....	19	0.4	3.38	–	8-22	0.6	5.15	8-21	9-6	0.9	9-30-18	1.0		
8-7.....	20	0.5	13.98	–				8-21	9-6	2.4	9-30-18	3.0		
8-7.....	21	3.1	7.12	– –	8-22	2.0	6.28	9-3			9-30-18	6.9		
8-7.....	22	0.5	8.54	–				9-3			9-30-18	0.7		
8-8.....	23	2.8	7.0	–				8-21	9.6	3.9	9-30-18	6.2		
8-8.....	24	0.6	7.93	–	8-22	1.0	4.26	9-3			9-30-18	1.4		
8-8.....	25	1.2	17.2*	–										
8-8.....	26	1.0	13.74	–	8-22	2.2	4.58	9-3			9-30-18	4.0		
8-9.....	27	0.6	6.07	–										
8-9.....	28	0.7	0.16	–							9-30-18	1.2		
8-9.....	29	0.5	10.5	–				8-21	9-6	0.8	9-30-18	1.5		
8-10....	30	1.1	12.7	–	8-22	0.6	3.26	9-3			9-30-18	0.5		
8-9.....	31	0.6	8.1	+ –	8-21	1.5	4.14	9-3			9-30-18	4.5		
8-10....	*32*	*0.6*	*8.02*	–				*8-21*	*9-6*	*0.6*	*9-30-18*	*0.5*		
8-10....	33	0.7	8.5	–	8-21	0.5	5.36	9-3	9-30	1.5				
7-19....	GI	5.2									5-20-19	0.8†	2.86	–
7-19....	*GII*	*5.6*												
8-21....	34	0.9	5.19		9-30	3.4								
8-21....	35	0.7	7.08		9-30	1.2								
11-2....	*40*	*1.8*	*2.5*	+ +	*11-29*	*2.0*	*1.65*	*11-2*			*5-20-19*	*0.9*	*4.90*	+
11-2....	41	0.9	1.6	+	11-29	1.7	1.80	11-2			5-20-19	0.5	4.22	+
11-2....	42	0.9	1.6	+	11-29	1.6		11-2			5-20-19	2.5	2.46	+
5-20....	*43*	*0.2*	*3.14*	+										
5-20....	45	0.7	4.65	+										

*Probably a mistake in calculations.
†The highly acid vinegar had been removed in the fall and replaced with new cider. This is evidently a poor practice.

"By comparing these data it will be seen that the acid and alcohol content of the different barrels of cider fluctuated considerably, but more often steadily but slowly decreased over a period of months.

"Only seven out of the thirty-seven barrels studied attained market standard acidity. These were barrels Nos. 12, 16, 17, 21, 23, 26, and 31. Of these barrels, Nos. 12, 16, 17 still contained *Bact. aceti* in sufficient numbers even after several months sojourn in cold storage so that inoculation was unnecessary. The contents of by far the greater number of barrels, however, were so injured by the microbial processes which took place at the low temperature that only four out of sixteen barrels inoculated with *Bact. aceti* were in a proper condition to form market standard vinegar after inoculation. It is thus quite evident that it is not an economic proposition to place sweet cider immediately, or at any time for

that matter for any length of time, at a cold or even a cool temperature if it is to be made into vinegar. The best temperature to maintain throughout the vinegar fermentation process is about 75 degrees Fahr.

"The contents of certain of the above barrels at the first analysis did not contain sufficient acid, nor enough alcohol, to raise the percentage of acidity up to market standard so an experiment was undertaken in a small way to determine whether the addition of sugar and inoculation with *Sacch. ellipsoideus* would have any effect in raising the percentage of alcohol and consequently acid. Five hundred cubic centimeters of each sample were treated as follows and inoculated with *Sacch. ellipsoideus*.

Barrel Number.	Sugar added.		Later additions.	Percent Acidity 2 months afterward.
	Amt. cc.	Kind.		
3	50	Karo	100 cc. Karo	2.0
12	50	Karo	100 cc. Karo	4.8
13	50	Karo	100 cc. Karo.... 100 cc. Duff's molasses	2.1
14	50	Karo	100 cc. Karo	3.9
16	50	Karo	100 cc. Karo	5.2
19	50	Karo	100 cc. Karo	4.5
28	50	Karo	100 cc. Karo	4.2

Karo was used on account of the sugar shortage. If no fermentation was noted in the course of a few days, other additions of sugar were made. If these results are any indication of those which would have been obtained had sugar in some form been added to the contents of the several barrels, then the addition of these amounts of sugar would have assisted considerably in the case of barrels Nos. 3 and 13, and greatly with barrels, Nos. 14, 19, and 28, while it would have been unnecessary with barrels Nos. 12 and 16. Unfortunately it is difficult to predict exactly just what will happen in the barrel but if these few experiments can be taken at their face value then the addition of sugar to weak vinegar followed by inoculation with the desirable yeast is to be recommended under similar circumstances.

"Honey vinegar of most excellent quality and high acidity has been made by Prof. R. H. Pettit of the Entomological Division of this station by diluting the honey, adding small amounts of peptone and potassium phosphate for additional nutriment and inoculating with pure cultures of *Sacch. ellipsoideus* and *Bact. aceti*. The elements contained in the chemicals above named are very necessary for the rapid development of the yeast but as they are not only hard to obtain in this form but expensive, experiments have been carried out using a number of different combinations of these same elements in a form which can be obtained readily and with small expense at any drug store, comparing these results with those obtained from the use of the more expensive ones.

"The following formulae were used:

I

250.00 c.c. diluted honey
1.18 gm. $(NH_4)_2SO_4$
0.20 gm. KH_2PO_4
0.025 gm. $MgSO_4$

II

250.00 c.c. diluted honey
0.20 gm. KH_2PO_4
0.50 gm. peptone

III

250.00 c.c. diluted honey
0.20 gm. KH_2PO_4
0.50 gm. Liebig's meat extract

IV

250.00 c.c. diluted honey
0.20 gm. KH_2PO_4

V

250.00 c.c. diluted honey
0.025 gm. $(CHOHCOONH_4)_2$
0.20 gm. KH_2PO_4

VI

250.00 c.c. diluted honey
0.20 gm. KH_2PO_4
0.30 gm. asparagin

VII

250.00 c.c. diluted honey
0.40 gm. $(CHOHCOOK)_2$
0.025 gm. $(NH_4)_3PO_4$
Trace of peptone

VIII

250.00 c.c. diluted honey
0.40 gm. $(CHOHCOOK)_2$
0.25 gm. $(NH_4)_3PO_4$

IX

250.00 c.c. diluted honey
0.25 gm. NH_4Cl
0.125 gm. NaH_2PO_4
0.125 gm. $KHCO_3$
(From Arizona Bul. 60)

X

250.00 c.c. diluted honey
0.25 gm. KH_2PO_4
0.25 gm. NH_4Cl

MAXIMUM ACIDITY OBTAINED.

Flask.	I	II	III	IV	V	VI	VII	VIII	IX	X	Percent sugar.
Percent acid as acetic	4.1	4.5	4.0	2.9	5.6	4.4	3.7	3.8**	*	*	
These cultures were less than 3 mo old	1.5	3.3	4.0	1.5	2.4	3.0**	2.7	2.3	1.8	3.9	10
	***	1.6	7.3	1.8	6.4	0.7	3.2	4.8	1.6	6.0	15

*These solutions were not tried the first time.
**Contaminated with mold.
***Flask broken.

"From the above results, the combination represented in flask VIII is suggested as available for general use with honey diluted to 15 per cent sugar.

"A small experiment was carried out using maple syrup diluted to 15 and also to 10 per cent of sugar, sterilized and inoculated with no additions of chemicals. The alcoholic fermentation did not progress very rapidly so a small amount of nitrogen was added in the form of 0.5 c.c. of egg white which had been removed aseptically. The flasks to which this was added showed a marked increase in fermentation over the ones to which nothing at all had been added. This suggests that the addition of a part of the white of an egg might be desirable as a source of nitrogen easily available, not only to the yeast as food, but to the farmer instead of the more expensive chemicals. Further experiments along this line are suggested.

"Different combinations of diluted maple syrup with various chemicals were also tried out. The following combinations were made and added to 250 c.c. maple syrup diluted to 15 per cent sugar.

I

0.05 gm. $(NH_4)_2SO_4$
0.05 gm. NaH_2PO_4
0.05 gm. Rochelle salts

II

0.1 c.c. egg white
0.05 gm. NaH_2PO_4
0.05 gm. Rochelle salts

III

0.20 gm. beef extract
0.05 gm. NaH_2PO_4
0.05 gm. Rochelle salts

IV

0.05 gm. NaH_2PO_4
0.05 gm. Rochelle salts

V

0.1 c.c. egg white
0.01 gm. $(NH_4)_2HPO_4$
0.02 gm. Rochelle salts

VI

0.01 gm. $(NH_4)_2HPO_4$
0.02 gm. Rochelle salts

VII

0.01 gm. NH_4Cl
0.01 gm. Na_2HPO_4.

VIII

0.01 gm. NH_4Cl
0.05 gm. NaH_2PO_4
0.05 gm. Rochelle salts

IX

0.1 gm. $(NH_4)_2SO_4$
0.1 gm. NaH_2PO_4
0.05 gm. KNO_3

X

0.1 gm. $(NH_4)_2SO_4$
0.1 gm. NaH_2PO_4

"The flasks which had been inoculated in January 1919 with *Sacch. ellipsoideus* were inoculated March 15th with *Bact. aceti*.

PER CENT ACETIC ACID.

Flask	I		II		III		IV		V	
April 15	a	b	a	b	a	b	a	b	a	b
	0.5	0.4	0.7	0.3	0.5	0.4	2.9	1.4	0.2	0.3
May 20	4.0	1.6	1.5	4.1	0.9	0.6	1.5	2.3	2.5	1.3

Flask	VI		VII		VIII		IX		X	
April 15	a	b	a	b	a	b	a	b	a	b
	0.2	0.3	0.2	0.3	0.2	0.4	1.2	0.3	0.3	0.2
May 20	1.4	0.8	1.5	0.6	1.0	4.5	0.8	4.0	5.0	4.2

"This suggests that the addition of certain chemicals as yeast food will greatly hasten the acetic fermentation. The combination in solution X is recommended for general use.

"A short experiment was carried out in the use of waste tomatoes for vinegar making. It was found that fully ripe tomatoes lend themselves best to this fermentation process. The tomatoes were washed, blanched,

cold dipped and the skins removed, sliced two or three times, put in an agate-ware pail and heated to the boiling point for a few minutes to extract the juice (no water is added), then strained through clean cheesecloth. The juice so obtained was used alone and with 10, 20, 30 and 40 per cent additions of Karo, inoculting it in each case with a pure culture of *Sacch. ellipsoideus*, later with *Bact. aceti* with the following results.

PER CENT ACETIC ACID.

	Juice plus Karo.			
Juice alone	10%	20%	30%	40%
0.9	Broken	4.1	3.8	3.9

"Twelve days after inoculation with *Bact. aceti*, in all three weeks after inoculation with the wine yeast, practically market standard vinegar was made in every case where sugar had been added. This vinegar is of good quality and has the tomato flavor making it particularly desirable in certain types of salads. Tomatoes unsuited for canning can thus be utilized to advantage. It is particularly advisable to pasteurize this type of vinegar when it reaches its highest acidity as it still contains considerable food material and microorganisms which will attack it and ultimately destroy the acid.

"Another experiment was conducted to ascertain the various concentrations of cider under which the vinegar fermentation organisms will work. The data are incomplete but the results so far obtained suggest strongly first that cider for vinegar-making will not bear much dilution* and that cider which has been boiled down to half of its original volume still can undergo the various stages of the vinegar fermentation. When boiled down to a third and to a fourth of its original volume, the cider would not undergo fermentation.

"Whey vinegar was also attempted in an effort to ascertain whether this would be a practicable method of conserving the whey from Cheddar cheese making. The suggestion was obtained from an article on 'Vinegar of Milk' found in a French periodical. This article suggested that it was practical only to add sugar or to evaporate the whey down to half its original volume as only about 5 per cent of lactose (milk sugar) is present. The flasks inoculated February 18, 1919 with a lactose-fermenting yeast were inoculated with *Bact. aceti* April 11th.

"The table following shows the results in brief:

Flask		Per cent alcohol April 10, 1919.	Per cent acid May 24, 1919.
I	Whey	2.90	2.2
II	Concentrated Whey	4.06	2.5
III	Whey plus 5% sucrose	6.11	3.8
IV	Whey plus 5% dextrose	4.30	3.1
V	Whey plus 5% lactose	4.95	4.4

*Later I found that these results coincide with those of B. T. P. Barker of the National Fruit and Cider Institute of Bristol, England.

"During the alcoholic fermentation the colloids which make the whey cloudy are separated out and after inoculation with *Bact. aceti* when a considerable amount of acid is present, the whey becomes very clear and is of a light straw color. The taste of whey vinegar resembles that of whey soured by *Bact. bulgaricum* and is not wholly pleasant to my taste at least. It is quite evident that the addition of sugar is necessary, and whether under these circumstances the manufacture of whey vinegar would be of economic value is a question.

"Pure cultures for vinegar making were instituted in 1910 at this laboratory. However, the August 1918 quarterly bulletin contained the first advertisement put out for some time, that the College Bacteriological Laboratory could furnish such pure cultures. That there was a call for some such thing to make vinegar-making successful is evidenced by the orders for cultures. At first the yeast and bacteria necessary for the vinegar fermentation were sent out in a combined culture, for twenty-five cents a culture, but experience has proven that in reality the so-called vinegar fermentation is two successive fermentations, the second depending on the first, and the organisms (yeasts) of the first stage of the vinegar process were hindered in their activities, often checked entirely even by the presence of the vinegar bacteria and their products. Consequently it was considered a wise step not to continue sending out mixed cultures, so beginning with the year 1919, the wine yeast and vinegar bacteria were sent out separately for twenty five cents per culture.

"The following is the report of vinegar cultures sent out from August 20, 1918 to June 25, 1919 inclusive.

Mixed cultures.	*Sacch. ellipsoideus.*	*Bact. aceti.*	Total.
132	16	31	179

"As yet a very few reports have been received from those using pure cultures, some are favorable and others are unfavorable as would be expected.

"Thirty analyses were made of cider or of vinegars which were not attaining sufficient acidity, and upon the results of these analyses, advice was given for treatment. The table showing these results follows: (The Hort. Dept. vinegar is not included in these results).

Sample No.	Type of vinegar.	Remarks	Per cent acidity as acetic acid.	Per cent alcohol by weight.	Reducing sugar.	Suggestions
48	Cider vinegar	Has been inoculated with *Bact. aceti;* acidity is dropping	1.3	0.28	+ +	Add wine yeast to boiled and unboile sample. *If no fermentation* then occurs add some light cooking molasses.
49	Honey vinegar	Made from waste honey with additions of phosphate, peptone and pure cultures	8.7	0.04	+ + +	Dilute to 4 per cent.
50	Honey vinegar	Made from waste honey with additions of *phosphate,* peptone and pure cultures	7.6	None	+ + +	Dilute to 4 per cent.
51	Honey vinegar	Made from waste honey with additions of phosphate, *peptone* and *pure* cultures	4.4	None	+ +	
52	Cider vinegar	Can sample be sold legally	5.7	None	+ −	Salable from standpoint of acidity.
82	Cider vinegar		0.8	4.99	−	Inoculate with *Bact. aceti* and furnish plenty of air.
83	Cider vinegar		1.1	7.14	−	Inoculate with *Bact. aceti* and furnish plenty of air.
84	Cider vinegar		0.5*	0.28	−	Inoculate with *Bact. aceti* and furnish plenty of air.
85	Cider vinegar		0.9	3.54	−	Inoculate with *Bact. aceti* and furnish plenty of air.
86	Cider vinegar		1.0	3.58	−	Inoculate with *Bact. aceti* and furnish plenty of air.
87	Cider vinegar	Cider diluted half with water was a year old; added 10 gallons new cider and 2 gallons cheap molasses	0.9	0.0	−	No remedy.
88	Cider vinegar	Three years old	1.1	None	−	No remedy.
89	Cider vinegar	Seems flat	0.9	15.84	+ −	Mix the contents of both barrels, put in
90	Cider vinegar	Inoculated with mixed cultures	1.0	4.3	+	warm place and inoculate with *Bact. aceti.*

91	Cider vinegar...	Inoculated with mixed cultures........	2.7	None	+	
92	Cider vinegar...	Inoculated with mixed cultures........	2.5	None	+	Put a quart of cheap molasses into each barrel and inoculate with *Sacch. ellipsoideus.*
93	Cider vinegar...	Inoculated with mixed cultures........	1.7	None	+	
94	Cider vinegar...	Inoculated with mixed cultures........	1.5	None	+	
95	Cider vinegar...	Is vinegar salable....................	5.4	None	++	Very good.
96	Cider vinegar...	Inoculated with mixed culture........	3.2	None	+	Add 4–5 *gallons fermented* cider or ½ gallons molasses to each barrel.
97	Cider vinegar...	Inoculated with mixed culture........	2.6	None	+	
98	Cider vinegar...	Has green-black color................	5.6	None	++	Fine with isinglass or gelatin and store in clean cask.
99	....	....	5.8	1.83	++	Draw off into clean cask, bung tightly and keep cool.
100	Cider vinegar...	....	6.4	Not deter	mined	Salable.
101	Cider vinegar...	Five months old......................	0.9	5.69	+	Put in warm place until fermentation ceases then inoculate with *Bact. aceti.*
102	Cider vinegar...	Sent in camphorated oil bottle........	1.5	3.38	++	Sent another sample.
103	Cider vinegar...	Six months old......................	1.5	6.64	++	Inoculated with *Bact. aceti*, and keep warm.
104	Cider vinegar...	1.5 years old; contains many foreign yeasts...........................	2.4	4.91	+	Filter, pasteurize and return to barrel after thoroughly cleaning and scalding it. Then inoculate with *Bact. aceti.*
105	Cider vinegar...	Is vinegar salable....................	6.5	0.53	++	Very good.
106	Cider vinegar...	About six months old................	2.0	6.38	++	Inoculate with *Bact. aceti.*

*Samples 82–86 were from one source. No. 84 was the only one which did not produce market standard vinegar experimentally.

"An increasing number of requests for information concerning vinegar making and vinegar 'bees' is being received from people both within and without the state. Correspondence has been carried on with several people in Iowa, Illinois, North Dakota, New York, and Nebraska, and vinegar cultures have been sent to one or more people in each of these states. So many requests for information or cultures were received form Iowa that the suggestion was made that perhaps their own state Agricultural College Bacteriological Laboratory could fill their needs more satisfactorily. Shortly afterwards a request was received from the Iowa State College Bacteriological Laboratory for pure cultures of *Sacch. ellipsoideus* and *Bact. aceti*. These were sent gratis.

"One firm sent a request for a sample yeast culture, requesting quotations on quantities, to furnish its patrons along with apple cider so that they might make their own apple wine—a practice which is allowed in their state. A culture was sent with the suggestion that they employ some one to propagate it if desired.

"Practically all of these requests for information or cultures call for a letter of explanation and as many of these letters have to be quite lengthy and a repetition of one another more or less, it seemed that a popular bulletin on vinegar-making as it applies to farm conditions would meet the increasing demand. Such a bulletin has been prepared.

Mr. Ruchle has devoted a portion of his time to other matters than his main project discussed elsewhere in this report. He was under the necessity of teaching the classes in dairy bacteriology because of the absence of Mr. Cooledge with the A. E. F. He reports on this work as follows:

"The work of a popular nature consisted in (a) monthly analyses, grading and inspection of the East Lansing milk supply, (b) answering numerous letters of inquiry, (c) making analyses of dairy products from dairies having various kinds of troubles as follows:

"(1) Sediment and bacteriological tests of the milk as delivered to Wells, Abbott, and Williams Halls, when they were used as military barracks. The results were reported to the medical officers in charge of sanitation.

"(2) Ten samples of unsweetened evaporated milk were examined at various times for sterility. All were found sterile.

"(3) Three chemical analyses of solutions of chloride of lime used by a dairy for keeping the rubber parts of a milking machine sterile. Two were found to contain only the merest tract of available chlorine, while the third contained a satisfactory amount.

"(4) Two samples of milk brought to the laboratory by students at boarding houses in East Lansing. The first, examined during the winter, contained 3,200.00 bacteria per cubic centimeter mostly of the lactic type. The second, received in June 1919, contained many millions as shown by a microscopic examination. There was a mixed flora present.

"(5) Two cases of bitter milk fermentation were reported by dairy farmers. In both cases, analyses of the milk showed the presence of liquefying organisms which, when inoculated into sterile milk, produced a bitter flavor, identical with the original trouble.

"(6) Two samples of cow's milk were analyzed for butter fat for farmers by the Babcock method and a sample of human milk was tested for fat and solids.

"(7) Samples of milk from a farmer who was having trouble with slimy milk, which developed after the milk was drawn were sent to the

laboratory for analysis. At the present writing a very short rod-shaped organism has been isolated; which produces a sliminess when inoculated into sterile milk tubes. The farmer has been advised to thoroughly sterilize all his utensils and to avoid getting any water into the milk during cooling. It is not known whether the instructions are being carried out.

"(8) Considerable investigation has been made of a serious trouble in a dried milk plant. The trouble consists of excessive foaming of the separated milk and of subsequent burning on the coils of the vacuum pan. The trouble is still being investigated and the partial results secured should not be reported at the present time."

Research Assistant C. G. Nobles returned and resumed his work in January of this year, but resigned April 1st to engage in farming in New York state. He was a good worker and carried on his investigations and routine duties faithfully at all times. We were fortunate in procuring immediately the services of Dr. Robert M. Snyder to carry on the project without any halt or delay. Dr. Snyder reports as follows:

"The work with the symbiotic and non-symbiotic nitrogen fixing organisms has been conducted by Mr. Charles G. Nobles up until April first of this year. The research carried on by Mr. Nobles concerned itself primarily with the influence of soil type and soil fertility on nodule formation. This work is being continued now after an unavoidable interruption due to the war. Field studies have been outlined for this summer which will, it is hoped throw further light on this problem. During the coming year nitrogen fixation studies will be undertaken in connection with Adams project 2c.

"Only a few reports on legume inoculation have been received this past year from farmers and others to whom cultures have been sent. In order that more information as to the exact measure of success attending the inoculation of certain legumes may be obtained, it seems desirable that those using cultures be more forcibly impressed with their obligation to report the results. Efforts will be made to obtain this information through county agents, and by circulars sent to the farmers at the close of the year."

CULTURES SENT OUT FROM JULY 1, 1918, TO JULY 1, 1919.

	*Alf.	S. C.	R. C.	A. C.	W. C.	F. B.	S. B.	G. B.	F. P.	C. P.	V.	G. P.	Total.
July	266	25	11	2	......	......	17	......	......	1	48	......	379
August	329	23	27	2	......	......	1	......	......	6	143	......	531
September	65	11	7	1	......	......	......	......	......	......	99	......	183
October to March	509	245	202	36	1	2	3	......	20	......	19	3	1,040
April	1,563	562	317	38	......	3	67	3	132	6	62	8	2,761
May	695	164	39	9	3	15	633	5	41	16	20	3	1,643
June	609	51	30	1	......	65	367	......	......	23	5	......	1,160
Total	4,036	1,081	633	89	4	85	1,097	8	193	52	396	14	7,688

*Alf., alfalfa; S. C., sweet clover; R. C., red clover; A. C., alsike clover; W. C., white clover; F. B., field bean; S. B., soy bean; G. B., garden bean; F. P., field pea; C. P., cow pea; V., Vetch; G. P., garden pea.

Assistant Bacteriologist F. W. Fabian has had very little time to devote to experimental work during the year. He did not leave the army until the close of 1918 and has been overburdened with classroom work since. He reports as follows:

"Work was started in June in conjunction with Mr. G. L. A. Ruehle on a comparison of three different methods of titrating bacterological culture media with a view of determining which was best suited to laboratory routine and which method would give the most uniform and correct results when samples of water obtained from different sources were used. The hydron ion concentration was also determined for each sample of water and likewise for each kind of media titrated."

Each year we are called upon to make a number of analyses of water samples from the rural sections of the State. Mr. W. L. Mallmann has interested himself in that work during the past year and reports in summary:

"During the past year, 120 samples of water were tested from various parts of the State. Fifty-five of these samples were from rural districts The greater portion of the samples were taken from open shallow wells or shallow driven wells. Unfortunately, data concerning the well and its surroundings did not always accompany each sample nor was information always received through later correspondence. The data if obtained would probably give some interesting information.

"Of the 55 samples from rural districts 16 were pronounced unfit for domestic use without boiling. This number is not high, considering the fact that all the samples received were suspected of pollution.

"At intervals the College and East Lansing water supplies have been examined. Every test showed the water to be free from any contamination.

"During the winter, a survey of the septic tanks installed by the College was made by the Farm Mechanics Department. Working in cooperation with them, samples of well water collected at the farms visited were obtained and shipped to the laboratory. In all 18 samples were tested. Five samples were obtained from deep wells. None of these showed pollution. The remaining 13 samples were obtained from shallow driven or open wells. Four of these wells showed decided pollution, the count running as high as 140,000 bacteria per c.c. The other samples did not show any colon organisms but showed a high count. Most shallow wells show a high bacterial count due to the surface water entering the well."

In conclusion I wish to commend highly the members of the departmental staff for the past year for their loyalty and devotion to their problems under exceptional circumstances, to thank you for your patient and kindly attitude at all times toward our work and to express the hope that not only may our staff be restored to its full quota, but that more men and funds may be made available for the many important problems discussed in this report.

Respectfully,
WARD GILTNER,
Bacteriologist.

East Lansing, June 30, 1919.

REPORT OF THE BOTANICAL SECTION.

Dean R. S. Shaw, College.

Dear Dean Shaw—I wish to make the following report for the work of the Botannical Section for the year ending June 30, 1919.

The chief work of the section has been along the lines of Plant Physiology and Plant Pathology, respectivaly under Dr. R. P. Hibbard and Dr. G. H. Coons, whose reports are appended herewith as part of my report.

Owing to war conditions, Dr. G. H. Coons devoted less time to his Adams project inasmuch as the results to be obtained from that would not be so easily and immediately applicable to agricultural practices. He devoted a portion of his time to work with the War Board of Plant Pathologists, a body consisting of pathologists chosen from all over the United States and Canada for the purpose of collaborating in the investigation and demonstration of plant disease control, so that the most important problems should be emphasized and the less important ones passed by until the war should be over.

The work of this Board was of very great value inasmuch as it made possible the much closer cooperation of the Plant Pathologists of the different states in the investigation of smut control methods, potato diseases, etc.

Mr. H. C. Young began the investigation of a very important project on plant nutrition, but had to suspend the work in order to enter the United States Army, from which he expects soon to be released.

Owing to necessity of outside war work in teaching S. A. T. C. classes and on account of the reduced teaching force, I was unable to continue with my experiments on electrical determination of viability of seeds.

On account of the war the U. S. Department of Agriculture and the Heinz Pickle Company thought it unwise to renew their cooperative agreement with this Experiment Station regarding pickle diseases, in particular cucumber mosaic. I have been carrying on some experiments on this subject throughout the winter and spring, but have been sadly handicapped by inadequate greenhouse facilities, for these investigations require living plants as a disease cannot be studied except in actively growing plants. The causal organism is not known and has never been grown outside of its host. The investigation has a wider value than the cucumber crop merely, for other plants are badly reduced in their yield by similar mosaic diseases which may or may not be caused by the same pathogene. These plants are potato, tomato, bean, soy bean, clover, tobacco, etc. Of these the potato mosaic threatens to become a very serious factor, particularly in the Upper Peninsula. It seems probable that any light that can be thrown on one of these diseases will help the understanding of the others.

The Experiment Station staff at the beginning of the fiscal year consisted, so far as botanical researches are concerned, of myself devoting a small portion of my time to the work, except during the summer; Dr. R. P. Hibbard who devotes about two-fifths of his time to teaching Plant Physiology and the remainder to his research work; and Dr. G. H. Coons with about the same proportion of his time to teaching and investigating Plant Pathology; H. C. Young devoting full time to a physiological problem. As mentioned above Mr. Young left at the end of August. About

March 1st Mr. Ray Nelson returned to the position to which he has been appointed the year before but from which he was called by the draft shortly after beginning his work. Mr. Nelson devotes full time to investigating plant diseases.

Respectfully submitted,
E. A. BESSEY,
Botanist.

East Lansing, June 30, 1919.

Professor E. A. Bessey, East Lansing, Michigan.

Dear Professor Bessey—In accordance with your request I herewith submit the report of work in Plant Physiology for the fiscal year ending June 30, 1919.

As per the plan of previous years the work has been divided between the Experiment Station and the College, the allotment of time being approximately the same as during the last fiscal year.

ADAMS FUND WORK.

The Adams project (Adams 2d), entitled "The absorption of solutes with special reference to balanced solutions", was pursued actively. It has assumed large proportions and is being carried on in the field on a large scale. The practical application of this project rests in working out from the data collected and to be collected a logical and reasonable method for determining the fertilizer requirements of soils and crops. The evidence so far is very strong in favor of adopting a certain method, but further field work should be done for a period of several years, so that definite conclusions can be drawn. The plan should also be modified to include the idea of crop rotations. Similar work is being done at the Maine and Pennsylvania Experiment Stations. At both of these stations the work is under the direction of one man. The problem here was independently conceived and planned, and worked out as a result of laboratory and greenhouse study carried on here for the past several years. Our first field studies were started on an acre of land in Field 10, during the summer of 1918. The results show that, for the particular soil used and under the then existing climatic and environmental conditions, an application of a mixed fertilizer containing a large amount of acid phosphate gave the greatest yield of oat grain and straw. That acid phosphate alone would not be the best fertilizer treatment was shown by a poorer yield of grain on the plot treated with acid phosphate only. Where a little sulphate of potash and sodium nitrate were used in conjunction with the acid phosphate the best yield was obtained. This shows, as has also been shown in greenhouse and laboratory work, that the evidence is strongly in favor of the use of other fertilizer salts to correct the unbalanced conditions in the soil solution when it is deficient in some necessary salt.

During the winter months a similar experiment was set up in the greenhouse. The soil was from the same field only not from the part that had received fertilizer applications. Two-gallon crocks were used in which to grow the crop. Instead of oats this time we used another cereal—wheat, of the Marquis variety. Altho this experiment should be repeated or should be run in duplicate to be ideal, the results show that acid phosphate again should be the chief ingredient in the fertilizer for this particular soil. It is our intention to repeat this experiment immedi-

ately, for it was out of the question to duplicate it as suggested above, because it would be a difficult matter to take care of 96 large cultures and carry them to maturity. The wheat grew well under greenhouse conditions and was normal in all respects except that it took a little longer for it to mature.

Later, other soils as well as other crops should be treated by this plan. A determination of the best ratio of combination of fertilizer ingredients appears then to be the best way of working out the fertilizer requirement of soils or crops, far better in fact than by making use of the chemical analysis of the soil or crop. During the winter several preliminary and five complete short term experiments were set up with corn, wheat and oats to determine various points in doubt in the general problem.

The spring before the close of the fiscal year three field experiments were started. The first was layed out on the Station farm, on poor, sandy soil. The piece of land was about two acres in size. The crop was oats. With the results of last summer's experiments before us we were able to see which changes and modifications were necessary in our plan. This time we emphasized two things: first, the various combinations (36), and secondly, the total amount of fertilizer added per acre. This is the same as determining the total concentration. This is an important matter especially when taken into conjunction with the various combinations, for it is probable that here as well as in water cultures the total concentration has much to do in determining the optimum ratio or combination.

The other two experiments were with crops and soil types with which we have had little or no experience. One of these was set up on the farm of L. J. Reed '13, at Clio, Mich., on a sandy loam, poor in fertility. The crop was corn, and the piece of land about three acres in size. The other experiment was on the farm of Ezra Levin, on a fine sandy soil. Here about two acres were set aside for the experiment and put into potatoes. These experiments are all on a small scale and do not include the idea of rotation of crops. As most farmers use the rotation system it seems very necessary to incorporate this into our general plans. Although most farmers would hesitate to spend the time and money on this problem under present labor conditions, it was gratifying to learn how ready both Mr. Reed and Mr. Levin were to cooperate. When such a plan of fertilizer treatment as worked out by the above method is widely known and established it is very probable that even then the farmers will not have time to use the plan in detail. In view of this fact, it might be the best thing for them to send the soil to the laboratory and there a study would be made along the line of the above investigation. From the results, a proper fertilizer treatment could be recommended to the farmer.

To assist me in the routine work of carrying on the above experiments, I have had with me for the year Mr. Gershberg, who has often put in overtime, has shown a zeal and earnestness in the work and has stayed on when other positions have been offered to him. Much of the success attained in these experiments is due to his hard work. I had often planned more than could be done, but we both worked hard and somehow or other things were accomplished.

STATE FUND WORK.

Early in the year plans for enlarging and broadening the work of the Experiment Station were outlined but on account of war conditions,

which reduced the number of men available for research and common labor, these plans had to be modified and reduced. Mr. H. C. Young was appointed Research Associate in Plant Physiology and given the following problem: "The physiological effect on life processes of certain plants when growing under deficient or improper nutritive conditions." Shortly after his appointment, Mr. Young was called into army service as a Lieutenant in the Sanitary Corps, and the work on the problem was stopped.

I regret to report that but little experimental work has been done on our cooperative experiment, to-wit, a study of the electrical conductivity of seeds. I have had the matter in mind considerably, planning various ways of attacking the problem.

COOPERATIVE WORK.

In addition to the above work, this division is cooperating in two other problems. We are collecting soil temperature data for the Ecological Society of America. Dr. Shreve of Tucson, Arizona, is in charge of the big problem, and we note that many states are cooperating for the purpose of carrying out a soil temperature survey throughout the United States. Next month will complete a year's record of soil temperatures at this Station. Our second cooperative problem is with the National Research Council. This problem is one of very great importance and many experiment stations throughout the United States are at work on it. The formal statement of the problem is, "The determination of the salt requirements of agricultural plants". All the workers aim to find out what combination of the necessary elements in the soil gives the most satisfactory growth of plants. On account of the lack of help and large amount of time necessary for our own work we have been able only to get a good start in this cooperative problem.

INSTRUCTIONAL WORK.

The work in the college included as usual, graduate and undergraduate instruction. With the absence of Mr. Young in the army, all the lectures and laboratory work in plant physiology fell to me. Courses were given in the fall and spring terms. During the time that the S. A. T. C. was stationed here, I was called on to take charge of Bacteriology 3 in the fall term, and found it a pleasure to do the extra work. I also assisted Mr. Seeley with his class in meteorology, putting in seven hours a week. I gave the usual yearly lectures on plant nutrition to the class in agricultural chemistry. I also lectured to the senior class in pedagogy, outlining a course of study in plant physiology for high school students. Certain experiments were set up and demonstrated at the time.

I wish to call attention again to the crowded condition of both laboratory and greenhouse. We appreciate that we have had more greenhouse space than usual due to your willingness to give up your bench, but even so our entire space for housing work in systematic botany, pathology and physiology is far too small for work of such importance. The experiment station laboratory is also crowded, and more space should be had at the earliest possible time.

For your sympathy, cooperation and willing assistance in all the varied interests of plant physiology, I wish to give you my many thanks.

Respectfully,
R. P. HIBBARD,
Research Associate.

East Lansing, June 30, 1919.

Dr. E. A. Bessey, College.

Dear Dr. Bessey—At your request, I present the following report of the work of the year. It may be pointed out that research work done during the war period necessarily took on a different character in some respects from the work of previous years. Certain lines of fundamental research which are carried on under Adams projects were laid aside for work of an emergency nature. For example, it became very evident that seed treatment of grains to prevent smut was a matter of state and national concern, and all forces of the Experiment Station were concentrated in the attempt to develop methods suitable to the grave situation brought up by the needs of the food crisis and the labor shortage. The results of the work on grain treatments are given in another place in this report.

As is evident from your own discussion of the personnel of the department, the war made many changes in the staff and prevented in part the carrying forward of experiment station projects. It is gratifying, however, to be able to report that by means of various assistants, chiefly women, it was possible to continue nearly all the lines of experiment station endeavor. And finally, it should be pointed out that the call for extension work in plant pathology was more pressing during the war period than ever. This work, in part, took the form of preparation of articles for the college press service and in part the giving of lectures and demonstrations at farmer's schools, institutes, etc. It must be conceded that extension activities and experiment station activities are difficult to reconcile, although it is certainly true that certain kinds of extension work can best be done by the experiment station, having first-hand knowledge of the facts. It is believed, from the work carried on, that the Experiment Station work has not been unduly injured by the demands of the war period, but it is to be admitted that work of a purely extension nature should not be pushed in peace times to the extent made necessary by the war. With this introductory summary of the general conditions under which the work of the fiscal year ending June 30, 1919, was done, I will proceed to report on the various projects being carried on under my direction.

ADAMS 5B.

This project is entitled: "To determine with some plant pathogenes of the Fungi Imperfecti, biological relations which may give a basis for identification and classification as well as understanding of physiological and life history problems. The Fungi Imperfecti form a group which at present has no basis for classification other than a highly artifical one. Attention will be concentrated on the section of the group represented by the genus phoma and its close allies."

The project as outlined is a very important piece of research work, and one which involves the development of a new technique in handling fungi. It recognizes, in the first place, the great complexity of the forms of the *fungi imperfecti* and the present unsatisfactory methods of diagnosis and classification. The purpose of the investigation is to determine biological methods whereby the organisms may be classified. For the purpose of the experiment, some fifty cultures of organisms of the Sphaeropsidales are carried in pure culture and these cultures have been maintained. During this work on the pure culture of several members of each of the important genera, it has been found that there are certain characters of mycelial growth which are constant for the genus. Certain peculiarities of growth and

pyramidal formation have been noted and these seem to be desirable characters which will be of service in diagnosis. A large part of the work has concentrated upon the inoculation of laboratory animals as described in the last report. The work done has confirmed the conclusions of last year's work, namely that animals can be sensitized by a given organism and will show anaphylactic shock when reinoculated. While there is doubtless a group sensitiveness it has been possible with certain Fusarium strains to get definite discriminative reactions in cases where a species and a variety of the species has been used. For example, guinea pigs sensitized with *Fusarium conglutinans* will not respond to *Fusarium conglutinans callistephi* but will respond to inoculations with ground material from the original culture.

In the preparation of antigens in this work the technique developed during the war for the preparation of oil vaccines has been used. Cultures are grown in bulk in a synthetic medium and after about two weeks growth the heavy mat is ground, by means of steel balls, under aseptic precaution in a large Pyrex bottle. The synthetic solution used is one designed to give a maximum of mycelial growth and is made up as follows:

SYNTHETIC SOLUTION.

Cane Sugar $(\frac{n}{50})$	7.2	gms.
Glucose $(\frac{n}{50})$	3.6	
Magnesium sulphate $(\frac{n}{200})$	1.233	
Potassium acid phosphate $(\frac{n}{50})$	2.72	
Potassium nitrate $(\frac{n}{50})$	2.02	
Tap water	1000.	

The work undertaken so far may be considered as an attempt to develop a technique suitable to handle the problems underlying this project.

HATCH.

Work under the Hatch Fund consists of the general routine diagnosis and determination of laboratory material and the development of the Plant Disease Survey. About 800 specimens were handled last year. This work keeps the department in touch with conditions in the State and gives to county agents, especially, definite information concerning the diseases prevalent in their counties.

In cooperation with the federal office, a survey of potato disease conditions in the State was made last year by Dr. E. F. Woodcock. It was the purpose of this work to watch for the first outbreaks of Late Blight of Potatoes in order that the epidemic conditions of 1912 and 1915 might not be repeated in war times. Due to the dry summer. Late Blight did

not appear. The experience in Wisconsin, however, where similar work was in vogue, demonstrated the practicability of this reconnoisance system. With wet weathei in the first half of the season, Late Blight would have been prevalent, and the warning given would have been most helpful in preventing loss. The full report of Dr. Woodcock's observations on Potato Diseases is to be published in the Twentieth Report of the Michigan Academy of Science.

A general summary of plant disease conditions of the year has been prepared and this is in course of publication in the Twentieth Report of the Michigan Academy of Science.

The work of the Experiment Station on cucumber diseases under your direct charge, carried on in cooperation with the U. S. Department of Agriculture, is also financed from this fund. Similarly your work in continuation of observations on ginseng diseases is financed from this fund.

From time to time calls for investigation of various diseases of crop plants come to the Experiment Station. Greenhouse troubles, especially, call for attention. From time to time, workers in the Experiment Station answer these calls and give such help as the disease conditions warrant. In passing it may be said that the diseases of greenhouse crops are numerous and exceedingly important. One of the chief factors governing the success or failure in the greenhouse business is control of plant diseases. It is to be hoped that more attention will be given to the pressing problems confronting the greenhouse industry.

STATE POTATO WORK.

For some years a portion of my time has been devoted to the investigation of potato diseases. A large part of the work done has been to interpret for Michigan conditions the findings of various scientists upon the extremely puzzling and elusive diseases—Mosaic, Curly Dwarf and Leaf Roll. It may be said that due to the facilities afforded by the fund allotted to potato work to attend the various conferences of workers on potato diseases, there has been made available to Michigan growers the results of all the research work of plant pathologists in these important and little understood diseases. The observations by Dr. Woodcock have shown that Michigan is in rather fortunate condition in respect to these diseases in comparison with other great potato-producing states.

Emphasis has again been placed in the potato work upon seed treatments for the prevention of Scab, Black-Scurf, and Black Leg. During the war period, the experiments of the Station gave plant pathologists in the various states grounds for great simplification of the methods of potato seed treatments. In place of the rather long period required for soaking potatoes for Scab (1½ hours in formaldehyde, 1 pint to 30 gallons) it was found that 15 minutes was effective. Similarly a 30-minute soak in corrosive sublimate 1-1000, is as effective—and apt to be less injurious to stand—than 1½ or 2-hour soak in the solution. These conclusions, based on one year's work are now reinforced with the results of a second year's trials. The full report of these experiments is at present being prepared for publication.

As a new contribution toward the solution of potato seed treatment problems, the work of last year brought out that mercuric cyanide* 1-1000

*I am indebted to Mr. Ezra Levin for the suggestion to try mercuric cyanide in this connection.

can be substituted for the mercuric chloride. The advantage of mercuric cyanide as a chemical for this purpose comes in its great solubility and also from the fact that it is not corrosive to metals. Potato treatments on a large scale require such a large equipment of barrels, tanks, etc., if treatment is to be done rapidly, that many farmers find the matter exceedingly onerous. If mercuric cyanide can be furnished at all cheaply to farmers, it will be a great advantage for their metal stock tanks can be used for treatment—the same to be carefully rinsed before using for the ordinary purpose again. Work with mercuric cyanide is being continued.

STATE CELERY WORK.

For some years the Experiment Station has worked on the celery diseases of the State. Attention in the last two years has been given largely to root diseases. The disease known as celery stunt has been kept under observation and selections of apparently resistant plants made. In no case has it been possible to winter over any of the selected plants. Plants which were growing in thoroughly sick soil and which were apparently free from disease when planted in the greenhouse or in the cold frame, rot in a month or two, indicating a partially diseased condition or an outgrown diseased condition at the start. Search for resistant plants and the attempt to winter them will be continued.

Since our first surveys of the prevalence of celery stunt the disease has been found in many other locations in the State. The disease is known now from every muck area of the State, although in all but Kalamazoo the disease is localized in its attack. The wide spread of the disease has been accomplished by the sale of diseased seedlings—a trade which is very brisk among market growers, especially in years when freezing or drought destroys seed beds in any given locality.

Golden Self-blanching celery is chiefly affected by the stunt, and in ordinary years Easy Blanching celery can be grown at a profit in diseased soil. Around Kalamazoo, the Easy Blanching is the chief celery grown. So far it has been marketed at a fair price.

Reports from other northern states indicate that the Michigan situation in regard to celery stunt is duplicated with them. It is evident that the Golden Self-blanching celery, which is the plant most highly prized on the markets is becoming exceedingly scarce. It seems extremely probable that in a very short time high lands can profitably be turned to the growing of this plant, by proper irrigation, and by the taking of proper precautions to prevent the entrance of this disease.

PHOMA ROOT-ROT OF CELERY.

Last year's report contained a short abstract of work done by the writer upon this interesting disease of celery roots. Last year, Mr. C. W. Bennett undertook fuller study of this disease. He has done most excellent work and greatly advanced our knowledge of the disease. After verifying the work previously done in the laboratory, Mr. Bennett has worked out details of methods of infection, has studied the causal organism in pure culture and determined its physiological relations under various growth conditions.

Most interesting and important as a contribution to the science of plant pathology are the results obtained in the loss of virulence. Mr. Ben-

nett worked with three strains of the *Phoma apiicola* known to cause this disease and finds in them great differences in virulence. The detailed report on the causes of loss in virulence in connection with growth in pure culture, in soil cultures and under various growth conditions can not be outlined here. The finding, however, that the organism changes its growth in soil away from the host plant, suggests very forcibly that by the operation of this principle "sick" soil becomes safe after some years of crop rotation. Work along this line is being continued.

CEREAL DISEASE INVESTIGATIONS.

Work on cereal disease was done under my direction by Mr. H. H. McKinney whose work in this regard was most carefully done. Following the outline of work given in the previous report in which the "Dry Method" for cereal treatments was tested and found safe so far as laboratory tests would show, the treatment was recommended for use with all cereals.

The treatment which the farmers in Kent county had first tried and found safe, when recommended in general throughout the State was used by some farmers carelessly with the result that grave injury to stand resulted.

The facts in the case during the fall of 1917 were these: Farmers had used the seed treatment for oats and had good success in control of smut. No injury to stand resulted in spite of wide variations in the hands of many farmers in seed treatment methods. This hardiness of oats tended to make farmers careless in their treatment of wheat the following planting season. Coupled with this the weather of 1917, was exceptionally rainy so that the planting of a given lot of seed extended in most cases over a period of a week to a month. Under such conditions many reports of loss came to the department. It was not sufficient for us to show disobedience of the very plainly given directions. It devolved upon the Experiment Station to discover the why's of formaldehyde injury.

This work which was done by Mr. McKinney and myself showed first of all that our knowledge of formaldehyde action was extremely limited. We had a rule for treatment but no principle treating on the method of action of the gas. We discovered that the prevailing notion that formaldehyde is a gas tending to escape readily is erroneous, and that on the contrary the formaldehyde as applied to grain by the wet method is extremely slow to air, since the formaldehyde polymerizes so readily. Furthermore, it was found that formaldehyde has a remarkable affinity for water, and that it cannot be driven out of water by boiling, even. These and other significant facts governing the use of formaldehyde developed in the course of our investigations. A complete account of work to date has been prepared for publication in the Twentieth Report of the Michigan Academy of Science. The results important for use by farmers have been given briefly in a popular bulletin.

It is gratifying to note that as a result of the work on the technical side, the formaldehyde injury question, our county agents, and through them the farmers of the State have been thoroughly informed of the dangers from careless treatment and as a result of this emphasis in following directions carefully not a single case of injury to stand came to the attention of the section last year. While here and there some farmer used formaldehyde carelessly, the great majority of the fields treated were protected from smut without injury to stand.

As a further result of our investigations, it was found that injury has been brought about for years by improper use of the wet method, and this loss, though important, has been over-looked or assigned to some other factor.

BEAN WORK.

The work of the Experiment Station has been reported in full in other reports. Mr. Muncie closed his work in 1917 and submitted full report of his findings, which has been published in Technical Bulletin No. 38. Mr. Ray Nelson, Mr. Muncie's successor has taken as his problem, Bean Mosaic. Although work by Mr. Nelson was interrupted by his absence from the Station for about nine months during the first of the year, many interesting observations on Bean Mosaic have been made. The statements of Cornell investigations that the disease is carried in the seed have been amply confirmed. It has been shown by observations on the diseased plants that the most pronounced mottling occurs in the new leaves, in the parts of the leaf nearest the veins, indicating the significance perhaps of the vascular system in transference of the virus.

It is too early in this investigation to report on the many lines of experimentation under way dealing with Bean Mosaic. Suffice it to say that it is the opinion of the members of the Experiment Station staff that in the mosaic group of diseases we have what are potentially the most serious of all plant diseases. Here is a great group of troubles, whose cause probably is an ultramicroscopic organism transferred in most cases by insects, capable in some cases at least, of wiping out an entire industry. There are places in Michigan where Peach Yellows is a household word and where peach growing is no longer attempted. There is a variety of potatoes, Bliss Triumph, that no one can raise at a profit. There are cucumber fields that have never produced a dollar's profit, and salting stations that have been sold for a song. All these are examples of the result of the work of a mosaic disease. That such a disease is at work in Michigan bean fields warrants most intensive investigation and it is the purpose of the Experiment Station to attempt to discover the seriousness of the present situation in Michigan fields.

In this connection, permit me to refer to the very promising fact that the Robust bean developed by Professor Spragg of the Farm Crops department seems, in Mr. Spragg's latest tests which have been carefully checked by both Mr. Muncie and myself, and by tests at Cornell University by Dr. Donald Reddick, to be extremely resistant to Mosaic. In this bean there seems to be the resistant character which will afford material for abundant work in plant breeding.

MISCELLANEOUS WORK.

Interesting results on the injury to plants by phenol fumes have been obtained in a series of experiments conducted by Miss Gillette, a student assistant in the laboratory. These results have been prepared for publication. Work on transportational diseases, in connection with Mr. Nelson, is being continued. Mr. Nelson has obtained very important results showing the importance of asphyxiation, such as results from poor ventilation, high temperature, etc., in connection with a wide range of crops. Work along this line is being continued.

PUBLICATIONS.

The following publications have been made or are in the course of publication at this time:

The Stinking Smut of Wheat—G. H. Coons. Extension Circ. 17.

Michigan Plant Diseases of 1918—G. H. Coons.

Potato Diseases in Michigan in 1918—E. F. Woodcock.

Formaldehyde Injury to Grains—G. H. Coons and H. H. McKinney. Twentieth Rept. Mich. Acad. Sci.

Injury to Vegetation by Phenol fumes—G. H. Coons and Genevieve Gillette. Twentieth Rept. Mich. Acad. Sci.

RECOMMENDATIONS.

In consideration of the wide range of work which is demanded of me in fulfilling the requests which come to the section from people in the State, permit me to urge the fact that one or two additional research assistants who are capable of taking charge of a line of endeavor, such as Mr. Nelson does, are necessary to get quickest results in many of the lines of investigation being carried on at the Station. Potato diseases are so important that a man should be provided for full time work. Similarly greenhouse and truck crop diseases should have a full time man to carry on most efficient investigations. The work I have been able to do has been limited and for the most part carried on through graduate students or through under-graduate assistants. The direction of this work takes much time away from my regular lines of research.

Most imperative in the carrying out of our work is the need for another greenhouse, fully as large or larger than the present one. The present greenhouse is used for five purposes, which, in spite of the most amicable relations in the section, interfere one with another. These uses of the present greenhouse are as follows: *First,* the greenhouse furnishes classroom material for all the teaching work in botany and plant pathology. *Second,* there is carried here a considerable stock of ornamental plants, some of which are of use for demonstration purposes. *Third,* the greenhouse is used by graduate students in plant pathology. *Fourth,* the experimental work in plant physiology which is most important and exceedingly far-reaching in its significance, is carried on here. *Fifth,* from 3 to 4 experiments in plant pathology work with diseased plants are carried on in this area.

It is evident from this showing that our greenhouse facilities are sadly inadequate. It is a fact that 25 years ago the College as a whole had more greenhouse space and was doing more for an infant industry—the greenhouse business—than it is today. Considering the value of crops grown under glass, alone, around Detroit, Grand Rapids, and every other city of any size in Michigan, this condition is open to criticism.

I wish respectfully to urge that you use every effort to impress the authorities of the institution with the inadequacy of the greenhouse facilities of the College and the department, especially to the end that more money may be provided at once for more space.

In order that this report may be complete and show the full activities of the year, I will state that I have spent considerable time in extension work. The chief activity has dealt with cereal seed treatment. The results obtained are to the credit of the county agents of the State who have been

most efficient and helpful in the campaign carried on. The following summary of work done in the various states has been prepared by the U. S. Department of Agriculture. It is a report of extension work which is, to my mind, in itself a justification of the existence of the extension work of the College. When we consider this as a contribution in the stress of a war year its significance is even greater.

TABLE I.

Results of a field survey to determine the prevalence of seed treatment by farmers and its effects in prevention of smuts.

State.	Number of farmers interviewed personally.	Number of fields inspected.		Inspected fields sown to treated seed.		Smut found in			
						Treated fields.		Untreated fields.	
		Wheat.	Oats.	Wheat.	Oats.	Wheat.	Oats.	Wheat.	Oats.
				Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Alabama	668	237	560	10.5	3.2	0.0	1.73	3.20	5.95
Arkansas	184	132	78	0.45	0.0	0.0	0.0	2.35	7.35
Georgia	225	136	141	38.9	22.6	0.05	0.10	4.47	10.65
Illinois	111	54	59	0.0	18.6	0.00	0.21	6.65	7.38
Indiana	477	159	390	57.1	39.0	3.03	0.35	6.06	5.92
Iowa	536	195	214	4.10	6.5	0.030	0.053	1.36	1.37
Kansas	334	187	147	0.05	0.01	0.000	0.000	0.81	4.49
Michigan	98	18	31	66.66	70.96	0.031	0.018	10.16	6.52
Minnesota	678	688	540	16.2	18.6	0.87	1.23	3.99	3.07
Mississippi	328	174	218	8.5	6.8	0.73	0.72	2.72	5.69
Missouri	1,176	845	515	5.0	2.5	0.63	2.90	2.33	4.97
Nebraska	350	242	110	6.6	1.6	1.12	0.70	8.11	6.45
New York	793	887	571	6.2	25.4	0.00	0.71	0.23	4.30
North Carolina	364	262	108	38.0	4.34	0.086	0.00	1.49	11.11
North Dakota	300	155	67	71.61	50.74	0.254	0.67	5.61	11.83
Ohio	211	224	55	1.7	10.9	0.25	0.125	0.80	10.42
Oklahoma	360	184	180	0.0	0.0	0.00	0.000	0.36	6.15
Pennsylvania	544	414	78	0.0	17.0	0.00	0.166	0.171	4.50
South Carolina	156	79	67	50.6	10.4	0.00	3.1	0.43	7.76
Texas	416	186	207	2.0	0.6	0.00	0.25	0.08	4.26

The figures for the twenty states named are representative of the forty-three states in which seed treatment demonstrations and smut surveys were carried on.

Figures furnished by the U. S. Department of Agriculture.

As is evident from the reports of the different projects, I have been able to carry out the work done because of most efficient and loyal help from my associates in the Experiment Station. I wish also to thank you for counsel and advice upon the many problems which have been before us.

Very respectfully,
G. H. COONS,
Plant Pathologist.

East Lansing, June 30, 1919.

REPORT OF THE CHEMICAL SECTION.

Director R. S. Shaw:

In summarizing the work of the Chemical section for the past year it seems fitting to make a public record of the services rendered by members of the staff, in connection with the world war. Six members of the staff were registered in the first draft, four of whom later entered the service.

Mr. F. F. Hebard, Inspector, resigned November 15, 1917, and en-

listed in the Naval Reserve Corps as a Seaman 2nd class. He early qualified as a marksman and was detailed as an instructor, which duty he performed throughout the remainder of the war.

Mr. E. J. Miller, enlisted in the Sanitary Corps, October 19, 1917, and was commissioned 1st Lieutenant. Lieut. Miller was placed on detached duty in Washington where he was engaged in the poison gas investigation. He was released December 28, 1918, and returned to his position February 1, 1919.

Mr. Percy O'Meara, was drafted November 30, 1917. He was sent to Camp Custer and assigned to Co. C. 338 Inf., 85th Div. On July 21, 1918, he sailed for France and returned to this country April 11, 1919. In September 1918 he was made corporal of his company. Corp. O'Meara was released from service April 11, 1919, and returned to his position May 7, 1919.

Mr. T. E. Friedemann enlisted in the Sanitary Corps, February 28, 1918, and was sent to Camp Greenleaf, Fort Oglethorpe, Georgia, where he was assigned to duty in the laboratory of the General Hospital. Mr. Friedemann resigned on February 14, 1919, in order to accept a Fellowship at the Harvard Medical School.

Dr. C. S. Robinson was called to the Rockefeller Institute, New York City, March 1, 1918, to take charge of instruction in Clinical Chemistry. He was attached to the Institute Staff until June 6th when he received a commission as Captain in the Sanitary Corps. Capt. Robinson was released from the service January 8, 1919, and returned to the laboratory January 15th.

These men served well and faithfully in the positions to which they were assigned and we feel justly proud of their records.

By action of the State Board of Agriculture, Mr. C. F. Barnum was made Chief Inspector and was taken off the road early in the year to supervise the work of collecting samples of fertilizer and feeding stuffs. He has taken charge of numerous details in connection with the control work which has greatly relieved the burden upon the Chief of the Section.

Mr. A. H. Teske was appointed as inspector and entered upon the duties of the office October 1, 1918.

CONTROL WORK.

Fertilizer Inspection: During the year ending April 30, 1919, 323 fertilizer licenses were issued and 863 samples were collected and analyzed. The results of this inspection were published in Bulletin No. 283.

Feeding Stuffs Inspection: Bulletin No. 282 giving the results of inspection covering 919 samples collected during the previous year was published during September 1918. During the year just closing 1,533 samples have been analyzed. The results of the inspection show a steady increase in the quality of the feeds sold in Michigan so far as amounts of nutrients guaranteed are concerned. A large amount of very low grade and cheap feeds are still on the market and it would be desirable to amend the law at the next session of the legislature so as to exclude some of the poorer materials now being used.

It was necessary to try two cases in the courts during the year. The first case was against Watson-Higgins Milling Co., Grand Rapids, Michigan, for shipping unlicensed and untagged commercial feeding stuffs. The evidence was presented to the prosecuting attorney of Kent county and

a warrant was sworn out against John A. Higgins as Secretary and Treasurer of the Company. The case was tried before Justice Beebe at Sparta where the violation was observed. The case was decided against the Watson-Higgins Milling Co. and a fine of $25.00 was imposed by the court. The case was immediately appealed to the circuit court and was scheduled to appear on the spring calendar. We recently learned, unofficially, however, that the Judge ruled it out on the ground of no cause for action. Up to this writing we have not been able to obtain a report on the case from the prosecutor's office.

The second case was against the Coombs Milling Co., Coldwater, Mich., for shipping "Bran with ground screenings not exceeding mill run" without previously taking out a license. The evidence was presented to Prosecutor Knapp of Coldwater who very ably handled the case. The warrant was served against Mr. John C. Amendt, Secretary and Treasurer. Before the case came to trial Mr. Amendt appeared before the Justice, plead guilty and paid the fine of $25.00 that was imposed.

In connection with this case valuable advice was given by Mr. Sheridan Masters, Assistant Attorney General, for which acknowledgement is gratefully rendered.

Insecticide Inspection: Seventy-six samples of insecticides and fungicides have been collected during the past two months and are now being analyzed. The results of the inspections for the years 1917 and 1918 have been published as Special Bulletin No. 96 which is now ready for distribution.

HATCH FUND.

Since returning to the laboratory, Dr. Robinson has been devoting his attention largely to an investigation of the use of ammonium citrate in the determination of reverted phosphoric acid. This has reference to the determination of available phosphoric acid in commercial fertilizers. It is a very important subject and the results of his work will be of great interest to all fertilizer control laboratories as well as to manufacturers. The results of the investigation will soon be ready for publication.

ADAMS FUND.

Project 2b: "Absorption in relation to soluble fertilizer salts". Mr. Winter has been in charge of this work during the past year and has demonstrated that soils may become "acid" simply by leaching. In order to prove this some alkaline soils and soil forming rocks were set up and water charged with carbon-dioxide was caused to percolate through them for varying lengths of time. In every case an excess of basic material was removed and the remaining soils, after being thoroughly washed with distilled water were found to be distinctly acid to sensitive litmus paper.

A simple method for measuring the amount of "acidity" or lime-requirement is now being investigated. This method depends upon the measurement of the hydrogen ion concentration of a water extract of the soil by the colorimetric method. The results of this work are very promising.

Project 2ba: "The organic nitrogenous compounds in peat soils". Since Mr. Miller's return, he has been making a study of the acid amide content of peat soils upon the assumption that this class of nitrogen should be the most readily available as a source of plant food.

More work has been done on the investigation of the "Alkaline Permanganate" Method for the determination of availability of nitrogen in mixed fertilizers. The later results confirm the earlier conclusions and prove that the action of the permanganate solution is not confined to any one group or groups of nitrogen compounds. It does prove, however, that the solution acts on the less complex nitrogen compounds, such as the primary amines and probably the acid amides liberating the nitrogen most completely. The more complex compounds are acted upon very slowly and the action is progressive. Our results indicate that the method may safely be used to differentiate between the good and poor nitrogen compounds. This work will be prepared for publication as soon as possible.

Project 2c: "Absorption in relation to osmosis in soils." Nothing has been done during the past year. It is hoped that the investigation can soon be started again.

MISCELLANEOUS.

One hundred ninety two samples of a miscellaneous nature were examined during the year and in addition a great many samples of marl, of which no definite record was made, have been examined in order to determine their agricultural value.

The writer attended the meeting of the Association of Feed Control Officials in Pittsburg, January 13-14, 1919, and in February was called to Washington as chairman of the legislative committee of the Association of Feed Control Officials to attend a hearing in the Department of Agriculture on a proposed Federal Feeding Stuffs Bill.

The usual course of lectures on fertilizers was given by the writer to the short course students in general agriculture.

In closing permit me to thank you for the advice and counsel that you have always been free to give and to commend the faithful and loyal spirit of cooperation exhibited by all members of this section.

Very truly yours,
ANDREW J. PATTEN,
Chemist.

East Lansing, June 30, 1919.

REPORT OF THE ENTOMOLOGICAL SECTION.

Director R. S. Shaw:

Dear Sir—Following is a brief report of the work of the Section of Entomology for the year ending June 30, 1919.

The season has brought out a number of unusual insects, among which is the clover jassid or leaf-hopper, which occurred in the southern part of the State on clover, at Centreville it destroyed from half to three-quarters of the crop in some fields. This creature (*Agallia sanguineolenta*) did its worst work on high, dry land in the southern part of the State, and was fairly well distributed.

A jassid on potato, which caused tip-burn was fairly common during the latter half of the summer of 1918. This tip-burn which has, heretofore, been attributed to weather conditions was controlled by a spray of nicotine sulphate wherever the spraying was done before the leaf-hoppers acquired their wings. The insects pass the winter in hiding, under rubbish, and the destruction of all rubbish in late fall after the cold weather sets in, is the one way to gain permanent control, since spraying for them is only a half measure after all.

A spittle insect on clover is reported as being very plentiful at Chatham in the Upper Peninsula Sub-station fields. This creature *(*Philaenus leucopthalmus* var. *fasciatus*) deposits its masses of fermenting spittle-like excretions all over the clover, and while the clover does not seem to be destroyed yet the presence of the frothy mass is distinctly disagreeable and must injure the clover somewhat.

The corn root-aphis was present in unusual numbers, due to the upsetting of our regular established rotation. It is always liable to appear in Michigan when corn follows spring-plowed grass sod. This is because the ants are able to establish themselves in the grass sod and the ants foster the aphids. Land which has been under intensive cultivation, that is, which has been constantly stirred, is much safer for corn because the constant stirring does away with the ants.

The army worm appeared in several southern counties and many cases were reported—some of the real army worm and some which turned out to be other insects. The cold, wet spring favored army worms as well as cut worms and the latter were present in very unusual numbers all over the State. The Erratic Army Worm (*Noctua fennica*) appeared in cut-over districts in the north where it was confused with the true army worm. Being confined to non-agricultural land it did very little damage except to gardens that had been put in here and there in the cut-over land.

A *Crambid* or grass web-worm has been troublesome in young corn, where the larvae bore through the roots and stalks, at the same time spinning webs about the roots. These *Crambids* are found normally, in grass sod and establish themselves on corn whenever infested grass sod is plowed in the spring and corn is planted. Our unusual labor conditions, together with the up-setting of the established rotations in the attempt to grow grains, has led farmers to plow meadows late and to put in corn which has been followed by web-worm injury, often mistaken for injury due to the European Corn-borer.

* Identified for us by Edmund A. Gibson, National Museum.

For several years grasshoppers have been very bad in Antrim, Benzie, Charlevoix, Cheboygan, Crawford, Emmet, Grand Traverse, Kalkaska, Manistee, Missaukee and Roscommon counties. At the present time a crusade is being carried on by our extension expert, in cooperation with the county agent in these respective counties. A poisoned sawdust bait is being used. This sawdust bait is a substitute for the bran bait which, it is hoped, will cut down the expense and still do the work. It is made as follows:

1 bu. of hardwood sawdust
1 lb. white arsenic
1 lb. (scant) salt
½ pt. molasses
Water to make a stiff mash

Apparently this is proving successful at the present time. An encouraging feature of the outlook is that many of the grasshoppers are being attacked by a parasitic red mite, *Trombidium.*

The appearance of the European Corn-borer in the United States has naturally put the entomologists of all the states on guard to prevent the further spread of this most threatening of all pests. Thus far none of the real imported borers have been found, but many samples of other insects and of their work, closely resembling the work of the imported pest, have been sent in. They include the common stalk borer, *papaipema nitela, some Crambids,* and *Hadena fractilinea.* These latter borers have attracted more attention than usual, no doubt, due to their resemblance to their dreaded, imported relative.

The 17-year cicada made its appearance on schedule time but, as was to be expected, in smaller numbers than ever before and although many reports of damage were sent in it is likely that the damage was done by other insects working in the same trees, whose work was blamed on the cicadas.

The pale-striped flea-beetle did some damage to potatoes, beets and beans during the dry spell, but the coming of wet weather usually puts a stop to their ravages.

Cherry slugs, the larvae of sawflies, on cherries and pears, were also very numerous this season. They are usually killed by a spray of an arsenical but, unfortunately, the first generation comes while cherries are ripening and is, therefore, allowed to escape because one hates to apply arsenicals to ripening fruits. The second generation, however, appears in August and should be disposed of in order that the trees may be safe the year following.

At the present moment the Hessian fly is on the increase in Michigan. The lower half of the State is well seeded down with the flaxseeds at the present time and while little loss has as yet resulted, the insects are widely scattered. This is due to early seeding in the attempt to avoid winter killing. Two years ago the wheat showed little fly, and much wheat had died the previous winter owing to the severe cold weather while the wheat was thinly covered with snow. A year ago last fall a repetition of this loss was feared and farmers were advised to sow earlier than usual, since the fly was not very plentiful at that time and the need for grain was most urgent. The advice proved to be good, since a good crop resulted, but last fall when the attempt was made to get back to fly-free sowing

dates, it was impossible to do so, with the result that early sowing has favored the increase of the Hessian fly which is at present well established. A repetition of early seeding bids fair to result in serious losses next year.

The work of Doctor W. L. Chandler has progressed very satisfactorily. This spring an inquiry into the life history of the ox-warble (grub-in-the-back) was started, and three calves were isolated in a specially constructed, screened building, in order to shut out the parent flies of the ox-warble from depositing any eggs other than those under observation. Many larvae were collected from the backs of cattle in our herds and the adults bred. Thus far no success has attended the attempt to induce these flies to oviposit on the calves in the sheds. Neither could he get the flies outside to utilize his particular calves for purposes of egg-laying, although several were captured and attempted to do so. It would seem that the ox-warble will not oviposit in captivity. It is hoped that these difficulties may be overcome, however, amd definite information obtained from further attempts.

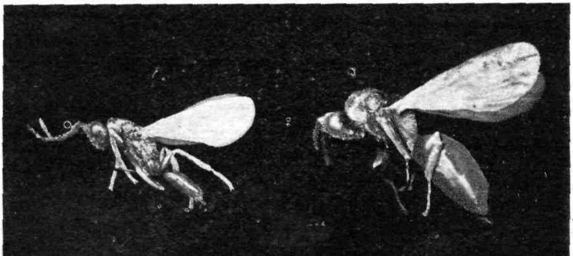
An experiment dealing with the determination and prevention of gapes in poultry was started this spring. Some very interesting data have been obtained, but it is too early to report the results as yet.

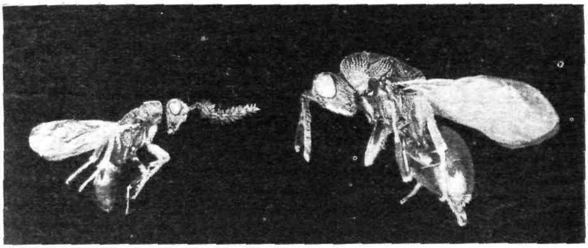
THE WHEAT JOINT-WORM.

BY R. H. PETTIT AND EUGENIA MCDANIEL.

A tiny wasp-like insect that induces swellings and woody growths in the straws of wheat and barley plants, causing some of the plants to bend at sharp angles and lodge, besides interfering seriously with the full development of the kernels.

Three times, at least, Michigan has suffered outbreaks of this pest—once in 1884, at which time Professor A. B. Cook records it; once in 1905 and 1906, which outbreak was observed by one of the writers, and once during the summer of 1918. This last invasion, like the others was wide-spread, but in this case, the common wheat joint-worm was accompanied in some counties by a less common species called the wheat sheath-worm, *I. vaginicolum*. While the common wheat joint-worm is always with us here





Parasite of wheat joint-worm (*Eurotoma bolteri*), enlarged (original).

and there, it is only at long intervals that it seems to be relieved of all restraint and to take possession of fields of wheat all over the country. Such occasions are undoubtedly brought about by weather conditions unfavorable to the parasites which ordinarily keep the pests in check. There is a continuous rivalry between the pest and its parasites as between the hunted and the hunter, and while the joint-worm occasionally gets ahead and makes trouble, just so surely in the past, the parasites have searched them out and destroyed all but an insignificant remnant—subsequently almost disappearing themselves for lack of sufficient food.

In the case of the common wheat joint-worm, *Isosoma tritici*, there is but one annual generation. The tiny, winged wasp-like insects emerge from their cells in the straw, usually in the stubble-fields, and lay their eggs in the wheat just after it begins to lengthen out in the spring. Each egg is pushed into a hole that is bored into the succulent straw at the tenderest spot, which is just above a node or joint. Sometimes a dozen or so eggs are scattered above each joint, although more often only part of the straw is utilized in this way. One can form a more or less accurate estimate as to the time when the eggs were laid in each field since the most tender, new growth is selected; for instance—straws attacked near the lower part of the plant show that the eggs were laid while the plant was

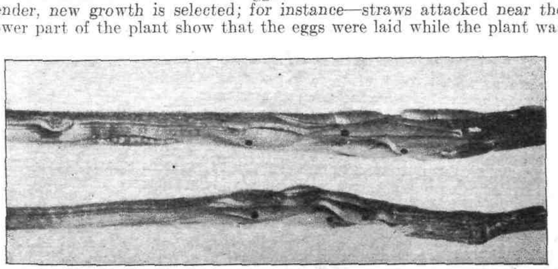


Fig. 3.—Swellings made by common joint-worms (*Isosoma tritici*) in straw, enlarged.

less advanced than those bearing the galls in the middle part or in the upper part. When the eggs hatch into larvae, their effect is soon noticeable in the thickened wall of the culm or straw proper. This thickening becomes apparent both by the increase in diameter and by the diminishing size of the bore in the straw, the central canal sometimes becoming completely closed. At this time, slicing the straw reveals cavities in the walls in which cavities are to be seen the grubs or larvae. The straw also becomes woody and often distorted so that in some fields one finds bent and twisted straws which refuse to stand erect, but lie on the ground instead, where they escape the reaper even if the heads succeed in filling.

The straws that are attacked seldom produce their full weight of grain, although the loss varies from a slight shrinkage to almost a total absence of seed.

At threshing time the woody sections are apt to break out in the separator, resulting in a lot of peg-like hard fragments from half an inch to three inches in length, and often this is the first intimation to the farmer that anything is wrong. Fortunately, few of the larvae in these woody sections live through the rough treatment that they receive during threshing, as repeated trials have shown us, since we have never succeeded in rearing any adults from such material.

The stubble from the same fields, on the contrary, usually yields quantities of adults when placed in beeeding cages, and in the stubble lies the danger, since it is here that the little fellows winter over. If our system of agriculture permitted the deep plowing of wheat stubble immediately after harvest, the trouble with joint-worm and several other troublesome pests would largely disappear. Our custom of using wheat for a nurse crop for clover prevents us from settling the matter in this way. There are left to us the employment of measures unfavorable to the insects and the substitution for a year or so of a grain crop immune to the joint-worm. The crop that comes most nearly up to our ideas of a substitute is rye, although rye is sometimes *slightly* attacked by the wheat joint-worm. Barley is often badly attacked and so far as Michigan is concerned, no other grain crop would be seriously and generally considered.

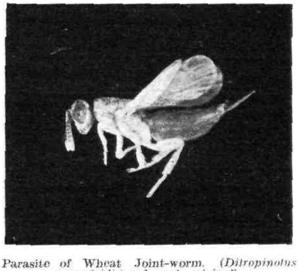
Wheat Joint-worm.—(*Isosoma tritici*) Pupa from cavity in straw, enlarged (original).

It must be remembered when considering practices unfavorable to the pests that the adult insects, when borne on favorable winds, fly the better part of a mile and it would be hopeless to even try to put new wheat fields at a distance of half that distance from old stubble. Nevertheless, it is well to avoid sowing new wheat any nearer old stubble than is necessary during an outbreak.

Since the insects winter over in stubble and comparatively few survive the journey through the separator, it follows that the shorter the stubble the fewer the pests that will winter there. Therefore, cut low. Some growers prefer to cut high and then after the old dead straws have rotted somewhat at their bases, to comb out the dead straws with a side delivery rake and destroy by fire. In no case should wheat follow wheat during an outbreak.

As soon as the presence of a serious outbreak became established, the department took steps to obtain samples of infested straw from standing grain, through its own members, the county agricultural agents, the State Crop Improvement Association, and through Professor A. C. Conger of the Department of Zoology, all of whom kindly assisted. These samples, numbering several hundreds, were collected for the most part, from the southern half of the State and were suitably caged and observed daily. During the summer thousands of parasites belonging to five species emerged from the caged straws. The following list is arranged in order of their numerical importance:

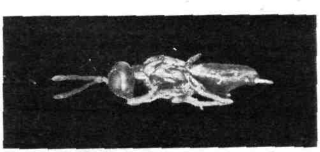
*1. *Ditropinotus aureoviridis*
2. *Homoporus chalcidophagus*
3. *Eupelmus alynii*
4. *Eupelminus saltator*
5. *Eridontomerus pruinosa*



Parasite of Wheat Joint-worm. (*Ditropinotus aureoviridis*) enlarged (original).

These parasites were pretty generally distributed over the lower half of the State, the *Ditropinotus* being by far the most common, and on several occasions this latter species was seen to be ovipositing back in the dried straws from which the adults had recently emerged.

The cages were placed in the cold room of our insectary so that the straw with the living joint worms and whatever parasites were present might experience approximately outside conditions. They were, however, brought into the warm room in March in order to hasten the emergence of such life as might be present. As a result, we obtained thousands of the joint worm adults and quantities of another species of parasite, *Eurotoma bolteri*, which closely resembles the joint worm itself in the adult stage. Last of all there emerged another large crop of *Ditropinotus*, evidently the result of eggs laid in the cages by the adults that had emerged during the previous summer.



Parasite of Wheat Joint-worm (*Eupelminus saltator*) enlarged (original).

This year (1919) the joint-worm seems to be scattered pretty well over the State, but only in comparatively few cases is the infestation

*Kindly determined by Mr. W. J. Phillips of the Bureau of Entomology.

as bad as it was last year. Some few fields in southern Michigan have suffered, but the situation as a whole seems to be markedly improved. The foregoing refers to the common wheat joint-worm, *Isosoma tritici*. The more serious species known as the sheath joint-worm, (*Isosoma vaginicola*) on the other hand produced comparatively few parasites in our cages, although it was not so widely distributed, being confined more especially to the eastern part of the State. The work of this species shows it to be still plentiful—possibly worse than in 1918. Several large fields are reported as practically worthless this year, while no one seems to find any improvement. To sum up the situation the common joint-worm is being rapidly destroyed by its parasites and the wheat sheath joint-worm is spreading somewhat, owing to the delay in the arrival of its own particular parasites.

Ditropinotus aureoviridis, with ovipositor inserted in wheat st aw, enlarged (original).

The survey of pathogenic parasites of food animals is progressing satisfactorily and thus far there has been no necessity for sending out to get material; that sent in for examination and the material obtained from post-mortems through cooperation with the Department of Pathology has supplied as much material as could be utilized. It appears that during the pursuit of this inquiry a few new records for the United States have been established.

During the year the following publications have been put out by the section:

Special:

"Spray and Practice Outline for 1919"—H. J. Eustace and R. H. Pettit.

Circular:

"Foul Brood"—B. F. Kindig.

Press Bulletins:

"House-flies and Influenza"—Doctor W. L. Chandler.

"Onion Maggot"—R. H. Pettit.

The following articles have been contributed to the Experiment Station Quarterly by the section:

"Stomach Worms in Sheep"—Dr. W. L. Chandler.

"Heat Insulators for Bee-hives"—R. H. Pettit.

"Entomological Notes"—R. H. Pettit.

"Round Worms in Swine"—Doctor W. L. Chandler.

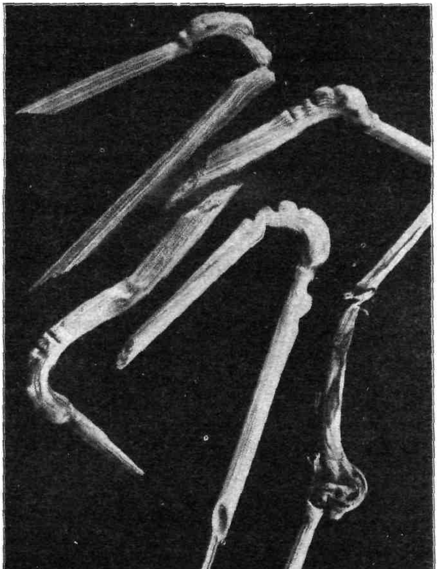
"New Pests for Which We Should be on the Look-out"—R. H. Pettit.

"Ox-warbles"—Doctor W. L. Chandler.

"Periodical Cicada"—R. H. Pettit.

On July 1, 1918, Doctor W. L. Chandler became a member of the Section of Entomology of the Experiment Station, having the title of

Research Assistant and devoting his entire time to the Experiment Station. At the beginning of the present fiscal year his title was changed to Re-



Work of the less common but more destructive joint-worm (*I. vaginicola*), also known as the wheat-sheath joint-worm.

search Associate in Parasitology and a part of his time was changed from Experiment Station to the Department of Entomology of the College.

Respectfully submitted,

R. H. PETTIT,

Entomologist.

East Lansing, Mich., June 30, 1919.

REPORT OF THE HORTICULTURAL SECTION

To the Director,

Sir:

I herewith make a report of the Horticultural section for the year ending June 30, 1919. The investigational work of the section has been concerned chiefly with such lines of work as have been previously reported. Progress has been made along these lines in the following projects:

DUSTING AND SPRAYING EXPERIMENTS*.

The work in this line was continued in the orchards at Morrice, Belding Muir, and Grand Ledge, using the various dusts and comparing them with the arsenate of lead and lime sulphur spray to ascertain the comparative values of these materials in controlling insects and diseases of apples.

MATERIALS AND APPLICATIONS.

Morrice:

The Dusting Mixtures used were home mixed, using 90% Niagara Dusting Sulphur and 10% Corona Dry Arsenate of Lead.

The Spraying Mixtures consisted of Dow Lime Sulphur 1¼ in 50, Toledo-Rex Calcium Arsenate (powder) 1 in 50, and the Dow Lead Arsenate (paste) 2% in 50. All the sprays were applied with the Friend and Hardie Spray Gun.

Applications. Four regular applications of all mixtures were made, both dusting and spraying.

Belding:

Dusting: Four applications were made according to the regular spraying schedule. First and second, 85-15 sulphur and arsenate of lead; third and fourth, Niagara 3 in 1 sulphur, tobacco and arsenate of lead. All materials mixed by the Niagara Sprayer Co.

Spraying: Dow lime sulphur, 1¼ in 50, and Dow lead arsenate (paste), 2½ in 50.

Muir:

Dusting: All dusting done by Mr. Wolverton, foreman at the orchard. Four applications. First and second, Sulphur 50%, tobacco 35%, calcium arsenate 15%. Third and fourth, 85-15, sulphur and arsenate of lead. All materials mixed by the Niagara Sprayer Company.

Spraying: Lime sulphur, 1 in 50, Toledo-Rex Calcium Arsenate (powder), 1 in 50, and Corona Dry Lead Arsenate 1½ in 50. All spraying done with Friend Spray Gun under high pressure, 225 to 250 lbs. Four applications according to regular schedule.

Grand Ledge:

Four applications of all materials. Friend Spray Gun used for al spraying. Materials used at the following rates:

Lead arsenate (Corona Dry): 1 in 50

* Note—For report of previous work see Special Bulletin No. 87, Dusting and Spraying Experiments with Apples.

Calcium Arsenate (Toledo-Rex Dry): 1 in 50
Dow Lime Sulphur: 1¼ in 50
Sherwin-Williams Dry Lime Sulphur, 3 in 50, the maximum amount recommended by the manufacturers.
Sherwin-Williams Dry Lime Sulphur, 5½ in 50, the amount necessary to get as much sulphur as is found in 1¼ gallons lime sulphur, 32° B.

RESULTS—DUSTING AND SPRAYING EXPERIMENTS—1918.

Variety and location.	Treatment.	Number trees counted.	Total number fruit.	Sound.		Scab.		*Insects		**Leaf R.		Codling.	
				Count.	Per cent.	Count.	Per cent.	Count.	Per cent.	Count.	Per cent.	Count.	Per cent
Baldwin at Morrice	*Dusted	3	12,115	11,893	98.1	91	0.7	131	1.0	......	......	0	0
	L. S. Calc. Ars.	3	9,462	9,008	95.2	91	0.9	363	3.8	......	......	0	0
	L. S. Ld. Ars.	3	13,354	12,695	95.0	151	1.1	508	3.8	......	......	0	0
	Check	1	2,282	1,995	87.4	26	1.1	173	7.5	......	......	88	3.8
Stark at Morrice	Dusted	3	9,885	9,632	97.5	191	1.9	63	0.6	......	......	1	0.01
	L. S. Calc. Ars.	3	7,819	7,436	95.1	202	2.5	176	2.2	......	......	6	0.07
	L. S. Ld. Ars.	3	7,461	6,924	92.8	398	5.3	122	1.6	......	......	20	0.2
	Check	1	1,229	643	52.3	202	16.4	67	5.4	......	......	348	27.5
Ba dw n at Belding	Dusted	4	6,371	6,168	96.8	109	1.7	74	1.1	......	......	20	0.3
	Sprayed	4	5,252	4,760	90.6	441	8.3	54	1.0	......	......	0	0.0
	Check	1	1,324	822	62.0	477	36.0	18	1.3	......	......	7	0.5
Spy at Muir	Dusted	2	2,104	2,007	95.3	39	1.8	18	0.1	35	1.6	5	0.2
	L. S. Calc. Ars.	2	2,562	2,461	96.0	33	1.2	3	0.1	65	2.5	0	0
	L. S. Ld. Ars.	2	3,656	3,462	94.6	28	0.7	2	0.05	163	4.4	1	0.02
	Check	1	540	477	88.3	32	5.9	1	0.1	30	5.5	0	0

Baldwin at Grand Ledge..	Lime S......	2	4,496	4,208	93.5	49	1.0	212	4.7	......	......	27	0.6
	Dry L. S. 3 in 50......	2	5,089	4,754	93.4	105	2.0	196	3.8	......	......	34	0.6
	Dry L. S. 5½ in 50....	2	4,272	4,062	95.0	45	1.0	138	3.0	......	......	27	0.6
	Check.......	1	2,116	1,454	68.7	154	7.2	171	8.0	......	......	337	15.9
Ben Davis at Grand Ledge	L. S. Calc. Ar.....	2	4,567	4,391	96.1	53	1.1	85	1.8	......	......	38	0.8
	L. S. *** Lead Ar.....	2	4,165	3,836	92.1	206	4.9	44	1.0	......	......	79	1.8
	Check.......	1	2,060	807	38.1	378	13.4	69	3.3	......	......	965	46.8

* Insects. In this class all insect injuries, other than by codling moth and leaf roller, are included. Nearly all of it is by the lesser apple worm.
** There has been no evidence of leaf roller injury except at Muir.
*** There were some factors, other than materials, which probably increased slightly the amount of injury by scab and codling moth.

SUMMARY OF RESULTS.

Morrice—The foliage of the dusted trees in the Morrice orchard was in better condition than of the sprayed trees. There was no injury and very little scab. The lime sulphur and lead arsenate spray caused a little foliage injury but much less than the lime sulphur and calcium arsenate.

The dusting gave slightly better control than the sprays but the amount was so small in every case that the only inference that could be drawn was that the dust was equally efficient.

Muir—The foliage of the dusted trees at Muir was in nearly perfect physical condition during the entire season. There was no scab on the foliage. The combination of lime sulphur and lead arsenate caused some foliage injury. This was not serious. The combination of lime sulphur and calcium arsenate caused severe burning of the foliage. This was much worse than on trees sprayed with lime sulphur and lead arsenate. The dusting work in this orchard has been uniformly successful during the past three seasons.

Belding Foliage—On dusted trees there was a very small amount of scab on the leaves and no spray injury. On sprayed trees there was no scab but a small amount of spray injury. On the check tree there was some scab but not enough to prove serious.

Fruit—The fruit from four dusted, four sprayed and one check tree was sorted and counted.

On the sprayed trees there was nearly six percent more scabby fruit than on the dusted trees, there being but one and seven-tenths percent of scabby fruit on the dusted trees.

The check trees developed a sufficient amount of scab to prove the comparatively values of these methods of scab control. There was practically no insect injury even on the check trees.

Grand Ledge—No conclusion can be drawn from this test of the relative value of using a larger amount of the Dry L-S. Powder as the scab did not develop sufficiently on the checks. A test was made of the lime-sulphur and calcium arsenate poison comparing it to the lime-sulphur and lead arsenate in controlling the codling moth worm and other insects. In most of tests with arsenate of calcium we have had more or less foliage injury; otherwise, the calcium arsenate has apparently been as efficient.

DUSTING CUCUMBERS AND SQUASH TO CONTROL APHIDS.

It has been found desirable to ascertain the effectiveness of dusts in controlling the insects and diseases of ground crops such as squash and cucumbers. The following is a report on this subject.

Materials. A mixture secured from the Niagara Sprayer Company and designated by them as "Niagara Contact Special Dusting Mixture" was used. The analysis given by them was:

Active Ingredients:	
Sulphur—not less than	49.00%
Nicotine—not less than	.25%
Inert Ingredients	50.75%
	100.00%

The 50.75% of inert ingredients is probably mostly tobacco dust as the percentage of actual nicotine in tobacco dust is quite low.

Equipment and Application. The dusting material was applied with the Ideal Power Duster. When dusting cucumbers the team was driven so that the duster was directly over the row and each hill was dusted as the machine passed over. If the vines were long enough to be in the path of the wheels they were easily turned so as not to be injured by team or wheels.

The outlet was held very close to the ground and swung from side to side so as to cover the entire hill. The leaves were easily turned up and in many cases the whole vine would be lifted from the ground so that the dusting material easily reached the under surfaces of the leaves.

Because of the large size of the squash plants it was not possible to drive over as with the cucumbers; the duster was driven along one side of the row.

Results. The under surfaces of the cucumber leaves were well coated with the dusting material, so that it was quite certain to come in contact with any aphids that might be there. Very few live aphids except a few of the winged form, could be found after a few hours from the time the dust was applied. With the squash it was impossible to distribute the dust to all parts of the plants. It is necessary to have the outlet quite close to the plants.

Conclusions. Aphids can be controlled by the dusting method when conditions are such that the dust can be brought in contact with them. This can be done with such crops as cucumbers or muskmelons, but not with rank growing vine crops such as squash excepting during their earlier periods of development.

DUSTING POTATOES TO CONTROL COLORADO POTATO BEETLE.

Materials. The dusting material used was a mixture of Dry Calcium Arsenate (Corona Brand—47% arsenic oxide) and talc. It was mixed in the proportion of:

Calcium arsenate	15%
Talc	85%

This makes a very fine, smooth, and easy-flowing mixture.

Applications. The dusting was all done with the Ideal Power Duster with the same outlet used for dusting trees. Four rows were dusted at each trip through the field, by holding the outlet pipe close to the plants and swinging it from side to side.

Work in College Gardens. Twenty-four rows in a potato field were dusted and the remainder of the field was sprayed with Calcium Arsenate at the rate of 1½ lbs. in 50 gallons of water.

Results. As soon as the dusting and spraying were finished a considerable number of plants in both plots that had a noticeable number of beetles on them were marked with stakes. Both methods were entirely successful. Within two hours after the application of the dusting material many of the beetle larvae were showing effects of the poison. No live larvae could be found the next morning (about eighteen hours after application) on either plot. Although there is no definite data for this

point, it is thought that the dust acted more quickly than the spray. This difference would be attributed to the greater concentration of the poison in the dust.

CONCLUSIONS.

This experiment indicates very strongly that dusting with calcium arsenate as described, is an entirely satisfactory method of controlling the larvae of the Colorado potato beetle.

There were very few of the adult beetles present when this work was done. Considerable difficulty has been experienced at times in controlling them by spraying. There is no apparent reason why dusting would not be at least as efficient as spraying, as the poison when applied as dust is usually in a more concentrated form.

STORING SMALL FRUITS AT TEMPERATURES BELOW FREEZING.

The work of the past year in the storage of perishable fruits was confined to those that proved the most promising in the tests of previous years; namely, the Montmorency cherries and the black raspberries. They were picked at the regular season of harvesting, treated in various ways and placed in the storage where the temperature was maintained at 18° to 20° F. In a general way it was found that these fruits kept better when stored in an air-tight container such as a Mason jar or even a crate wrapped tightly with paper. When stored in such a manner it was found that there was less shrinkage and less change in the color of the fruit during the storage period. Mold developed on the raspberries when not stored in air tight containers.

Montmorency cherries which were washed, stemmed and pitted, and then placed in Mason jars and tightly sealed were stored successfully from July until the following March. When removed from storage at the latter time the color, flavor, and general condition of the fruit were excellent. Cooking tests made from these cherries proved that the fruit was of a much higher quality for pies than when canned cherries were used or those stored in any other manner.

POTATO SPRAYING.

The work of the past season on potato spraying was confined largely to comparative tests of the arsenate of lead with the calcium arsenate as a poison to control the potato beetle. The tests prove that calcium arsenate can be used as a substitute for the lead arsenate with very little danger of foliage injury as there has been no foliage injury developed by either of these poisons in this test.

BUD SELECTION AND PERFORMANCE RECORDS WITH APPLES.

This work started in 1914, the past year completing the fifth season in which the section has been cooperating with the United States Department of Agriculture on obtaining records from a plot of 120 Baldwin trees at Belding in the orchard of Mr. B. F. Hall. Records have been kept for each of these trees as to the size, yield, and peculiarities of the fruit produced. While the records thus far show no great variations in the productiveness of the trees some very interesting and important variations in the type of fruit produced have been discovered. One of these important types has proved to be of very poor storage quality. This experiment will be continued the coming season.

EXPERIMENT TO TEST THE VALUE OF VARIOUS MATERIALS ON THE TRUNKS OF YOUNG FRUIT TREES TO PREVENT RABBIT AND FIELD MOUSE INJURY.

Seventy-five young trees were painted with the following materials: Concentrated Lime Sulphur, Lime Sulphur and Lime, Bordeaux Lime, Sulfocide, Lime Sulphur and Arsenate of Lead, Arsenate of Lead.

The trees were growing in a thick heavy sod, making conditions favorable for injury from mice.

The only material that seemed to have any apparent effect was the thick Bordeaux, as both early and late injury was apparent on practically all the trees in the plot. This test rather demonstrates the futility of painting the trunks of young trees to prevent rabbit and mice injury over winter. We would advise the use of the galvanized, four-mesh screen as the best preventative.

Considerable work was started by Mr. R. W. Peterson, Assistant Horticulturist, on Vegetable Plant Selection. Mr. Peterson was called into service and the work during the past year in this line was very limited. It is hoped to develop and extend this field of experimental work in the interest of the vegetable growers and the canning factories of the State.

Of the other lines of investigational work that have been continued the past year there is nothing of special interest to report at this time.

Mr. W. C. Dutton has acted as assistant horticulturist of the Experiment Station during the entire year, being the only one in the section giving his entire attention to experimental work. We wish to take this liberty of expressing our appreciation for his services during the past year.

H. J. EUSTACE.
Horticulturist.

East Lansing, June 30, 1919.

REPORT OF THE SOILS SECTION

Director R. S. Shaw, East Lansing, Michigan:

It is with pleasure that I submit to you the report of the Soils section for the fiscal year ending June 30, 1918.

The experimental and research work has been vigorously pursued. Five bulletins have emanated from this section, namely, Bulletin No. 91, Some General Information on Lime and its Uses and Functions in Soil, Bulletin No. 248, Some Information and Suggestions Concerning the Uses of Phosphorus, Technical No. 42, Relationships Between the Unfree Water and the Heat of Wetting of Soils and its Significance, Technical No. 43, Soluble Salt Content of Soils and Some Factors Affecting it, and Technical No. 44, Rate and Extent of Solubility of Soils Under Different Treatments and Conditions.

The various projects under way are as follows:

1. Soil management and studies. This involves investigations of the moisture and structural relationships of soil fertilizer needs with special reference to a proper balance of different elements of plant food, the immediate and residuary effects of different forms of lime, acid phosphate and raw rock phosphate respectively, the partial substitute of mineral fertilizers for stable manure, sugar beet fertilizers and the value of top dressing soils with mineral and organic fertilizers. These investigations at present include thirty field projects in different parts of the State,

some are quite elaborate, but owing to the fact that some of them are being conducted cooperatively on privately owned farms most of them are simple in nature.

2. Investigations of the value, nature and duration of the residuary effects of several forms of vegetable matter when applied to soils of different textures.

3. A study of the changes in the crop producing power and the physico-chemico-biological properties of soils long under cultivation.

4. The immediate and residuary effects of soluble salts on the physical and chemical properties of soils.

5. Translocation of soluble salts in soils and its relation to the amount, time and manner of application.

6. Field and laboratory investigations of peat and muck soils.

These investigations include temperature changes, moisture relationships, depth and nature of the subsoil, and fertilizer and cultural methods.

I desire to emphasize the fact that the members of the staff are greatly handicapped because of insufficient funds. You are aware of the fact that several neighboring states make larger appropriations for work of this nature than does the commonwealth of Michigan. This is not as it should be inasmuch as our soil problems are far more diverse and numerous than are those in the states to which I refer. We should establish, as several other states, experimental farms in the different regions of the state so that the work may be controlled and watched by the farmers who own land in them. Of course, these should be as permanent as the agriculture in the region, or should be continued indefinitely. We, as members of the Experiment Station force, are very desirous of seeing this brought about and shall not feel that we are performing our full measure of duty to the agricultural interests of the State until conditions are such that it can be done.

I desire to commend to you the splendid spirit that Messrs. Millar, Grantham, Spurway, Wheeting and Simpson have manifested while performing their arduous duties during this, an exceptionally trying year. In fact the success of our organization has been due in a large measure to this spirit and to permanency of the personnel. Each of us is grateful to you for your support during the year.

Respectfully submitted,
M. M. McCOOL,
Soil Physicist.

East Lansing, Mich, June 30, 1919.

REPORT OF THE FARM CROPS SECTION.

Director R. S. Shaw, East Lansing, Mich.

My Dear Sir—I submit herewith a report of the Farm Crops section for the year ending June 30, 1919.

The first half of this period was a time of intense war activity, and the last half marked the beginning of a period of readjustment along agricultural lines. The Farm Crops section was burdened with problems and difficulties of an unusual nature in addition to its usual duties. An unusually large correspondence developed relative to experimental work bearing on the war and readjustment problems of the State. Fortunately,

the experimental work of past years provided a sound basis for the answering of a great majority of these questions, and for directing extension work and publicity in proper channels to accomplish best results.

The need for the utmost production of food in order to meet war demands brought into use the full knowledge of this section based on numerous past experiments concerning crop varieties, crop adaptations, and cultural methods. For the most part, the experimental work of the past was directed along lines remarkably well suited to meet these needs. Here and there new lines of work were indicated by war needs which will be carefully considered in planning future work.

Comparative test of annual hay and forage crops.

The effort on the part of Michigan farmers to meet the demands for increased production of small grains, beans, corn, potatoes and sugar beets, resulted in the frequent breaking up of established rotations, and a decrease in the area of meadows and pasture lands. Without doubt, crop production in Michigan will be effected for a number of years and new problems will present themselves to farmers and agronomists. In addition to causing an increase in production of our chief food crops, the war gave impetus to the production of fibre crops such as flax and hemp; flax production in the State practically doubling, and hemp production being taken up in a small preliminary way in several sections. During the past season, about twice the normal acreage of sorghum was planted for syrup purposes, the largest acreage since Civil War times. Spring wheat figured as a crop of considerable importance, the acreage increasing from an inconsiderable amount to over 43,000 acres in 1918 and a further marked increase in 1919. Buckwheat production made a marked increase, as in Civil War times.

As a result of the decrease in the acreage ordinarily given over to meadows and pastures, the planting of short seasoned hay crops such as peas and oats, millets, sudan grass, corn for fodder, sorghum, soybeans, etc., was greatly increased.

The effect of the war was also apparent in its influence on our seed stocks and seed production. Owing to the cutting off of foreign importations of clover seed and unfavorable conditions for production, seed of this important legume was very scarce and demanded an extremely high price, ranging from twenty-five to thirty-two dollars per bushel for red clover and mammoth, and from twenty-two to twenty-eight dollars for alsike at retail during the spring of 1918.

During the past four years the production of hairy vetch seed (formerly imported from Russia) has increased very markedly in Western Michigan, and bids fair to remain as a permanent industry.

The production of seed of crops not usually handled in the State such as millet and alfalfa was noted in occasional instances. In the case of sweet clover the acreage was greatly expanded and seed production increased very considerably.

The alfalfa seed situation was bettered if anything by war conditions though the price was high and the seed not too plentiful. The cutting off of Turkestan and Arabian seed threw American producers on their own resources, and a much larger quantity of American seed was produced than usual in western states. The more wide spread use of seed from the northwest gave a much higher percentage of successes with alfalfa in Michigan. The acreage of this crop gained rapidly.

The rape seed on the market was almost entirely of Japanese origin, little of the Dwarf Essex being available from Europe.

The Michigan sugar beet companies, faced with the shortage of imported seed, increased the production of sugar beet seed to the extent that many of them were able to produce from one-third to one-half the seed needed for the acreages contracted under their direction. Sugar beet seed production before the beginning of the European war in 1914 was practically unknown in Michigan.

Threshing variety series of wheat.

The success of the Rosen Rye and Red Rock Wheat in this and other states, and the increased interest in improved varieties, brought these varieties into great demand. The Rosen Rye is now the most widely known rye variety in the United States, and an extensive seed demand from outside sources has arisen. The Red Rock Wheat is one of the most widely grown varieties in Michigan and is recognized by millers of Michigan wheat as being excellently suited for bread flour making purposes. When it is considered that these varieties left the hands of Plant Breeder, F. A. Spragg only seven years ago in the case of Rosen Rye, and six years ago in the case of Red Rock Wheat, the remarkable importance of this phase of crop improvement work is apparent. Further details in regard to the performance of these varieties will be given in Mr. Spragg's letter, included in this report, and the report submitted by Extension Specialist, Mr. J. W. Nicholson.

CROPS EXPERIMENTS.

In order to meet the need for information relative to the comparative value of short seasoned hay crops planted at various dates, Professor C. R. Megee was delegated to plant a comparative series including varieties of peas and oats, varieties of millet, sorghum, sudan grass, soy beans broadcasted, corn closely drilled, vetch and oats, et ceterá. This experiment gives promise of giving valuable results.

Extensive ear-row work and merging plat work with carefully selected ears of leading corn varieties was begun under the immédiate charge of Mr. J. R. Duncan. The usual variety test, including a number of varieties of known value and possible worth, was planted.

In addition, sectional variety tests including numerous oat and barley varieties were planted at sixteen different points in the State, ranging from Lower Michigan to the Upper Peninsula. Twelve corn variety tests at various points in the State were also arranged and planted. These tests were planted on soils ranging from muck to heavy clays.

Three and one half acres of the Crops department ground was again given over to the Bureau of Plant Industry flax work. This experiment includes the testing and increase of numerous pedigreed and commercial strains of flax, and also the effect of various fertilizer treatments on flax.

The Fibre flax nursery and increase plats.
(Bureau of Plant Industry U. S. D. A. co-operating with the Michigan Agricultural College)

REPORT ON PLANT BREEDING WORK.

The plant breeding work has increased to a considerable extent under the direction of Plant Breeder, F. A. Spragg. The acquisition of more land has made possible the planning of definite rotations including clover for the various small grain and cultivated crop breeding plats. In a recent statement, Plant Breeder Spragg gives the following facts in regard to the plant breeding work:

Crop improvement projects with the following crops are at present in process: alfalfa, barley, beans, broom corn, clover, corn, flax, hemp, oats, peas, rye, sorghum, sunflowers, sweet clover, timothy, vetch and wheat.

The work with these crops involves the following processes: variety testing; beds, centgeners, and plant notes; plant-row testing; milling and baking; increase; crossing and hybridization; segregation of hybrids; selfing; and inheritance studies.

ALFALFA VARIETAL SERIES.

The present series was planted in May 1918. It contains thirty-one plats including two edges, eight check plats and twenty-one other varieties. Seven of these varieties were produced in the alfalfa breeding work at Rocky Ford, Colorado. The remaining fifteen strains come from the breeding work at M. A. C. One of these is used for checks and edges.

Rosen Rye Improvement. Increasing selected strains of Rosen Rye which are planted in wheat series with heads protected from cross pollination by cheesecloth covering.

The alfalfa series furnishes a comparative yield test and increase of the better strains for distribution. This series should run for two years. The seed from previous nurseries has been distributed to county agricultural agents for increase in their various counties in order that a seed industry may be started. Alfalfa production in Michigan will be on a much more sound basis when the production of seed in Michigan is placed on a practical basis.

ALFALFA BREEDING NURSERY.

This nursery was set out in June 1918. It contains over 8,000 individual plants from which individual hay and seed yields are obtained. Plants that produce seed are tagged, hung up to dry, weighed, and threshed individually. The seed is placed in individual envelopes in order that individual seed records may be obtained, and to provide seed of those selected as mothers of the next generation. Non-seed producers are simply weighed and recorded. Threshing the seed, calculating the yields for hay and seed is done during the winter. The better producing plants from the highest yielding strains are then selected, and the selected seed sown about the first of May and the plants set out in the new nursery in June 1920.

BARLEY TESTING.

There are forty plats in the larger barley series, each 420 feet long and a series of thirty-one smaller plats including those that have come recently from the plant-row and centgener series. In the spring of 1920, these two series will normally be united into one large series.

BARLEY NURSERY.

There are 75 centgeners in the 1919 series belonging to the third filial generation from crosses.

BARLEY INCREASES.

The Mich-2-row and the Black Barbless barleys are being increased. This increase contains fifty-five rate of seeding plats including the necessary edges and checks. There are over two acres planted to Mich-2-row for increase.

BEAN VARIETIES.

There are one hundred ten plats in the 1919 varietal series. These are mostly strains that have successfully passed the plant-row series. Some of them are farmer's varieties which have been highly recommended.

BEAN NURSERY.

This nursery includes 161 centgeners originating from crosses made by Mr. G. W. Putnam during the winter of 1916-'17 and are in the third filial generation.

BEAN PLANT ROWS.

In the fall of 1918 over three hundred plant selections were made from the fields of thirty farmers widely distributed over the State. The purpose was to obtain new and more valuable varieties. Three hundred plant-rows were planted from these beans in 1919.

BROOM CORN.

The high price of broom material during the war aroused some interest concerning the possibility of growing broom corn successfully in Michigan.

In order to furnish small amounts of seed of the highest value, a number of individual plant selections were made in 1918. Eight of these were planted in the plant-row series of 1919.

CLOVER NURSERY.

The clover nursery contains six progenies and the checks and edges.

CORN SELECTION PLATS.

There are six corn selection plats, three of about one-half acre each, the others occupying less acreage. There are twenty-six plats in the plant-row series started by Mr. Down. The ears have been selfed and the notes taken to determine their trueness to type and the desirability of the various strains for increase.

HEMP CENTGENERS.

Hemp for fibre is a promising industry in Minnesota and Wisconsin. Michigan also offers a field for the development of this crop. In taking up the work in 1918, three beds were planted from the most promising strains that Mr. Dewey (B. P. I.) had to offer. One of these varieties failed to ripen, and the highest seed producing plant was selected out of each of the other plats. These two plants became the mothers of the centgeners in 1919.

OAT BEDS.

Ten of the beds were planted in 1919. Oat variety series and centgener work will occur in rotation in 1920.

OAT PLANT ROWS.

There are eighty plant-rows, the best ones of which will go to a one hundredth acre variety series in 1920.

OAT INCREASES.

Five varieties are being increased in 1919 to renew the pedigreed seed of the varieties now in the hands of the farmers commercially.

RYE SELFING.

When the Rosen Rye was first distributed it was frequently planted alongside of common rye and being open pollinated, was frequently crossed. In order to provide a source of pure Rosen Rye over three hundred plants were planted in the wheat variety series at the Experiment Station. These were staked and hooded to obtain self fertilized seed. This seed will be planted in isolated places for increase in 1920.

RATE OF SEEDING ROSEN RYE.

The tests planted for 1919 contain five rates of seeding, with checks and edges.

DATE OF SEEDING ROSEN RYE.

This test includes plantings beginning September 16, 1918, continuing at five day intervals until November 21st. Spring plantings have also been made on April 9, April 22, and May 13. The results have not been calculated, but the indications are that seedings made previous to October 15, gave much greater yields. Seedings made in late October and November gave comparatively light yields and the spring seedings failed to give a crop.

EARLY AMBER PLANT-ROWS.

Variety tests indicate that the Early Amber is best suited for Michigan. Plant selections were made of this variety in an endeavor to find better strains of sweet sorghums to increase.

SUNFLOWER PLANT-ROWS.

Sunflowers are attracting considerable interest for ensilage purposes, and during the war period was looked to as a possible source of oil suited for paint purposes.

The variety series of 1918 showed that all varieties tested were mixtures and most of them susceptible to rust. Selections were made that were somewhat resistant to rust for use in the plant-row series of 1919.

ANNUAL SWEET CLOVER.

An annual form of sweet clover, originated in the breeding work at the Iowa Experiment Station, is being increased.

TIMOTHY TESTS.

The lots of timothy seed originating from the selfing of four superior strains, produced from the breeding work of past years, were placed in a yield test last fall. The checks and edges are commercial seed.

TIMOTHY SELFING.

The four plants that proved to be the highest producers in the clonal series were divided and transplanted into separate patches in 1917. These were surrounded by rye in 1918 and again in 1919 to protect the strains from crossing.

VETCHES.

Selection work is being tried with spring vetch that came from Svaloef, Sweden.

WHEAT YIELDS.

There are forty-four plats in the 1919 wheat variety series. The varieties are mainly the new strains produced by the breeding work of previous years, including several other varieties. The series to be planted this fall will be considerably larger.

WHEAT BEDS.

Thirty-three new varieties were placed in beds in 1918 for selection in 1919.

WHEAT CENTGENERS.

There are one hundred and three centgeners. The 1919 nursery represents the third filial generation from crosses made in 1916.

WHEAT HEAD SELECTIONS.

Thirty head selections were made in 1918 for increase and testing in 1919.

WHEAT INCREASES.

Five new wheats are being increased to enable distribution for testing and to allow milling and baking.

WHEAT CROSSING.

Twenty-three plats were planted to enable the crossing work now needed in the progress of the wheat breeding work. These crosses were mainly between our best stiff strawed varieties and the weak strawed western varieties that have proved more winter hardy.

RATE OF SEEDING WHEAT.

The Red Rock Wheat was seeded at six different rates. This test includes the checks and edges necessary to a regular variety test.

DATE OF SEEDING WHEAT.

The work of the present season is a continuation of the work started by Mr. Down in 1917. The purpose is to discover the date suited to the highest average yield of wheat. The dates begin early in September and continue into October.

During the past year the following have been on leave of absence during military service.

E. E. Down, Corporal, C. O. H., 58th Inf., A. E. F. overseas service June 30, 1918 to June 30, 1919.

A. L. Bibbins, Sergeant, M. T. C. 375, A. E. F. overseas service, June 30, 1917 to June 30, 1919.

J. F. Cox, 1st Lieutenant, Air Service A. P., August 25, 1918, to January 1st, 1919.

During the absence of Mr. Down, Mr. Floyd Curtis has capably assisted in the plant breeding work. Mr. C. W. Straight was added to the staff as foreman of the field forces, this department having been carefully reorganized.

I take pride in reporting the patriotic spirit and unswerving endeavor on the part of the members of this department engaged in Experiment Station work during the past year. I am particularly grateful to Mr. F. A. Spragg for his attention to the management of the section during my absence.

Yours truly,
J. F. COX,
Professor of Farm Crops.

East Lansing, June 30, 1919.

METHODS OF PLANT BREEDING EMPLOYED AT THE MICHIGAN AGRICULTURAL COLLEGE.

F. A. SPRAGG.

The plant breeding work of the Michigan Agricultural College has produced several varieties of grain which have become important factors in the State. Of these, the Rosen Rye, Red Rock Wheat, and Worthy Oats are the most widely grown. At least seventy-five per cent of the rye grown in the State is Rosen, and the Red Rock is without doubt the most widely grown red winter wheat. When it is considered that these varieties were distributed in 1912 and 1913 respectively, the effectiveness of the combination of plant breeding work with a good system of distribution is apparent.

There have been many inquiries in regard to the methods followed, and in order to clear up these questions the following brief description is submitted.

VARIETY TESTING.

This work consists in the gathering of promising varieties from any and all sources that are likely to furnish them, viz., farmers, seedsmen, experiment stations, and through the U. S. Department of Agriculture from around the world. These lots are given accession numbers as they are received. The record includes name of variety, source, date received, amount received and remarks.

Wheat Variety Series—Red Rock used as check occurring every fourth plat. Note superior stiffness of straw of Red Rock (center row).

The varieties are planted in a duplicate series of long and narrow plats side by side, if land permits, or if not, they are planted in sections of the same. On either side of each section is an edge plat that exists simply to give the real edge of the series as nearly the same conditions as any interior plat. The yields of the outside edges are disregarded at harvest time.

The standard variety or check occupies the real (interior) edges of each section of the variety series, and is repeated on each fourth (or at least fifth) plat throughout the series.

At harvest time the yields are obtained carefully for each plat in the series. The interpretation of these results depends upon the yields of the standard, as found on the check plats, and as calculated for the other plats by interpolation. The coefficient of yield (calculated for each plat) is the quotient of the actual or found yield of the variety growing there divided by the calculated yield of the standard for the same plat. Or, considering the standard as 100% these coefficients of yield are the decimal expressions of the per cents that the varieties in question bear to that of the standard variety. An average is now taken between the two duplicate coefficients of yield obtained for a variety, in the same year. As these figures are based on unity, they are not influenced by the variations in the yield of the standard from year to year now on different soils. This makes it possible to average the yearly results, as long as they run without danger of obtaining a weighted average.

In all this class of work, the series planted in the earlier years include unimproved varieties of unknown value, but as time goes on the poor yielders are excluded and little by little improved varieties take their place.

BEDS, CENTGENERS, AND INDIVIDUAL PLANT RECORDS.

The individual seeds are planted far enough apart so that the roots will not interlock during growth, and at approximately equal distances that the individual plants may have equal chances to develop. In case of corn and beans the seeds are dropped by hand in rows of the ordinary field width. In the case of alfalfa the seed is planted in beds too thick for more than six weeks development. The better plants are then transplanted to positions three by three feet in the nursery which is a centgener in a plant-row series when the seed comes from a selected individual plant. The difference between a bed and a centgener is that the bed is planted from a lot of seed that is not a progeny. It may be commercial seed. A centgener is a progeny plat planted from the seed of a single plant. Beds and centgeners are planted by what is known as the centgener method of planting.

In the case of small grains, the seeds are usually dropped five by five inches apart by means of a special centgener planter in belts twelve plants (five feet) wide.

The more promising plants are selected out of the beds to become mothers of plant-rows, if they are homozygous, or they are planted in centgeners if thought to be heterozygous. The seed of superior plant-rows together with the centgeners, that did not segregate, are tested further in variety series.

Individual plant records are made with all of the plants in a perennial nursery like alfalfa where the results are not obtainable in any one year and selections can not be made until all of the results are together.

In the case of centgeners originating from crosses, the plants are classified into their phenotypes and counted. Then the superior individuals of each phenotype are tied up separately and taken to the laboratory for individual plant notes. Sometimes the segregations are such that a full classification can not be made until the plants are threshed individually

Alfalfa Improvement Work—Individual Plant Row and Individual Plant Study.

as in the case of wheat crosses involving color and hardness of grain. When such segregations are important, plant notes may need to be taken on all of the individuals of the phenotype involving the other desirable characters. The final selections are made on the basis of the segregations revealed by the individual threshing.

PLANT-ROW TESTING.

The seed from selected homozygous plants are planted in a plant-to-row series with frequent checks for comparison. The seed of selected heterozygous plants go to centgeners to allow segregation and reselection.

In the case of corn the ear-row test is in fact a row series of centgeners. Some of the plant-rows can be discarded at harvest time by inspection. Others go on to 1-100 acre plats and later to the regular variety series.

In corn work, ears from selfed plants will be subjected to the ear-to-row tests in order to decide on the most desirable and productive strains. Remnants of the ears will be saved for future planting.

Trueness to type is one of the main points to be looked for in the plant-to-row work. In the self-fertile plants these progenies generate pure-lines that can go directly into the variety testing work. In the case of corn and rye the problem is more difficult, and the types are fixed more slowly.

MILLING AND BAKING.

The problem is first to find a wheat that has the sufficient hardiness and yielding ability to justify quality testing.

The milling work began in 1911 with the wheats then in variety test and continued until 1916. It then became known that the Red Rock was the only one that stood a high baking test among the stiff strawed practical Michigan varieties. The work has rested for the production of new wheats from the breeding work. It is planned to resume the work in 1919 on wheats originating from crosses in 1912. The milling will be

done by us, but the baking will be carried through by the Department of Chemistry.

INCREASING.

New high producing strains that have proven their worth through testing in the variety series are grown in larger plats. The purpose is simply to obtain enough grain to allow distribution to farmers.

In this work, the aim is to distribute the best that the Station has to offer, and then to distribute other promising ones as they appear and demand presents itself.

Distribution sometimes occurs for the purpose of testing a new thing in various parts of the State. It is being realized that to discard all of those that are not the highest yielders at M. A. C. may mean the loss of a variety that would be of considerable value to the farmers of some locality. Distribution sometimes occurs because of a quality other than yield. As an illustration, a smooth awned barley has been distributed.

CROSSING AND HYBRIDIZATION.

The first thing is to see what nature has to offer. Thus in wheat the early years were devoted exclusively to pure-lines, isolation, and their testing in variety series.

Wheat Crossing Work—showing method of protecting spikelets after hybridizing.

When it became known in 1912 that the hardiest and best milling wheats were all weak strawed kinds and therefore unsuited to Michigan Agriculture, crosses were undertaken between them and the better stiff strawed strains.

The object of crossing is to combine characters found in separate

varieties that are not at present combined in any known strain. Crossing involves considerable work in the following generations before the new type can be fixed and tested.

In open fertile or allogamous crops, one must not forget that vigor may be lost through too rapid in-breeding.

THE SEGREGATION OF HYBRIDS.

For each alternative pair of hereditary characters in which the parents of the hybrid differ, a geneplex results. This, no doubt, means that a pair of chromosomes carry the determiner for these characters. One of these are of maternal and the other of paternal origin. They exist together in all the cells of the first generation hybrid. The two chromosomes of a pair come to lie side by side at the metaphase of the heterotypic division when the hybrid produce spores and eventually gametes.

What is true in the case of one genoplex will be true for the others. The resulting gametes will each carry one of the alternative characters of each genoplex. The various gametes will carry the chance combinations of these alternative characters. Thus after fertilization, the resulting individuals of the second generation come by the chance combinations of the resulting gametes. The second filial generation is thus composed of a mixture of individuals possessing all combinations of the segregating parental characters.

The seeds obtained from a cross are planted in a bed in the first filial generation, and from this bed selections are made to become mothers of the progenies of the second generation. The centgener method is used in planting progenies that are apt to segregate.

Self pollinating work with corn.

This is necessary to allow the classification of the plants into their phenotypes and to make individual plant selections for the mothers of the next generation.

In the case of the self-fertile crops, plant selections are made and centgeners planted in each generation until races breed true to seed. In the case of the allogamous (open fertile) crops the plants may need to be selfed in order to gain the purity desired.

SELFING.

Selfing is an artificial method of causing naturally allogamous plants to self-fertilize. This method results in what naturally occurs in the case of autogamous plants. Selfing allows homozygotes to appear and to be isolated. In corn the method consists in bagging both ear and tassel before the silks appear and before the pollen shatters. When the silks are ready, the pollen collected from the tassel is used to pollinate the silks on the same stalk.

SYSTEMATIC STUDIES IN INHERITANCE.

In making crosses, it often happens that characters are involved that are not familiar to the experimenter. In order to proceed intelligently it is necessary to make extensive statistics on the populations resulting from the generations following the cross, and to make the calculations necessary to determine the relation of certain characters correlated, allelomorphic, or independent. If allelomorphic (alternative) which character is dominant, and how many independent factors are involved in the gap between the two characters.

These questions may be answered by means of the following consideration:

a. Correlated characters are always found together in the same plant.

b. Dominance can usually be told by the appearance of the first filial generation. The dominant character is normally found in three times as many plants (in the second filial generation) as those that express the recessive character.

c. A pair of allelomorphic characters generate a single genoplex, and are probably represented by a single pair of chromosomes.

d. Independent characters generate at least two genoplexes, and must be represented by different pairs of chromosomes.

RATE OF SEEDING.

In the case of new varieties the grower should know the rate best suited for the planting. Varieties vary greatly in stooling power. The size of seed produces varying numbers of seed in a given weight and measure. This increases the need for experimental tests.

DATE OF SEEDING.

As crops and certain varieties also vary greatly in the way they adapt themselves to a season, investigations on date of seeding are as important as the rate of seeding.

OAT IMPROVEMENT.[1]

BY FRANK A. SPRAGG.

Looking toward the improvement of the Michigan oat crop, the important problems to be considered are the best variety to grow, and the cultural methods that will increase the production, regardless of the variety. One of these is just as important as another, since the best variety will fail if burnt up by drought, drowned by poor drainage, consumed by smut, or if starved to death for lack of plant food.

In seeking the best variety, many farmers are deceived by the conditions under which the crop grows. A typical case is that of a certain farmer, who had an extra high yield, which attracted such widespread attention, that other farmers traveled miles from all directions to buy seed from him. This farmer did not have a highly superior variety, which would continue to give better yields than other varieties under poorer conditions as many thought, but the high yield was largely due to the fact that he was a good farmer living on a rich piece of land improved by proper rotation and fertilization. He believed in plowing and fitting the land so as to give his seed *the best chances to grow. He used two hundred pounds of acid phosphate per acre* that his crop might stand up, mature earlier and produce better under his conditions. He believed in fanning out all weed seed and saving his crop from the ravages of smut by the simple formaldehyde treatment. This alone may have saved him ten bushels per acre that would have otherwise gone to smut the threshers faces, and make the passer-by think his barn was on fire because of the dust. Those who did not plant the seed that came from this splendid field under equally good conditions, suffered a great disappointment as they did not get the results expected.

A neighboring farmer of similar soil who used a high yielding pedigreed variety, but neglected some of these factors might have an inferior yield. Pedigreed superior varieties have greater capacity than ordinary varieties to utilize plant food and turn it into grain. They will therefore produce more than the unimproved grains under the same conditions. Thus we must remember that the selection of the variety while an essential to maximum production, is only one of a number of factors necessary for success.

Michigan has such a great variety of conditions (soil and climate), that it is not possible to obtain any one variety that will suit all of these conditions. There are the low flat, recently drained parts of Saginaw and Bay counties where Mr. DeGuss has introduced the Strube Oats with great success. There are ill drained conditions in some parts of southern Michigan where ordinary varieties are caught by hot sun before they are ready to ripen. Those localities may need extra early oats of the type of the Kherson, or Sixty Day. The Swedish Select is an old variety that seems to be especially suited to the north. It is also favored by scattered farmers

[1] The data contained in this paper having to do with the consensus of opinion among farmers, is largely compiled from data gathered by Mr. J. W. Nicholson, Secretary, Michigan Crop Improvement Association.

in the Lower Peninsula. Nearly every neighborhood has its favored varieties, and many people have suffered by discarding an old variety before they were sure that something better was in sight. It is best to test the new variety along side the old and make a change only when sure that the new variety is superior.

The Michigan Agricultural College has been breeding oats during the past twenty years, and in recent years some of the improved strains have been distributed through the Michigan Crop Improvement Association. It is desired that the farmers of Michigan will plant these varieties along side of their own and be the judge as to relative yields. In the end, there may be no variety superior for all conditions, but if each farmer can have the best variety for his own conditions, the greatest good is attained.

In order to draw reliable conclusions in regard to the productiveness of a variety, it is necessary to try it side by side with a standard variety under identical conditions. Because of the variability of soil, cultural, and climatical conditions, the bushels per acre are deceiving, unless the yield of the standard variety is also given. To express this in one figure the percentage method is valuable.

THE EARLY WORK.

The Alexander and College Wonder are two of the strains that originated in the work of Prof. J. A. Jeffrey who made sixteen individual plant selections from an old variety known as the American Banner in 1900, and so planted and selected them that the lines passed through an individual plant annually until 1906. By that time nine of the original sixteen races had been discarded as inferior strains. However, most of these lines had been allowed to branch, each branch being continued through an individual plant annually. One of the lines contained six such branches. In all nineteen strains of American Banner were handed to the writer in 1906. Similar selections were made from Big 4 in 1900, but all but two of these lines were dropped before 1906. These proved inferior to the Banner selections during 1906-1908.

In 1907, the writer planted Prof. Jeffrey's nineteen individual oat plants in separate plats for comparison, and was convinced of the similarity if not the identity of the lines, originating from a single plant in 1900. This series was again run in 1908 with similar results. By 1909 representatives of the various strains had been increased enough to plant in a 1-20 acre series, where the oat then grown on the College farm was used as a standard or check. The plats were six feet wide and about 360 feet long, with checks each fifth plat in the series. One of these strains was introduced to farmers under the name of Alexander in 1911, and a second was introduced in 1914. The latter is known as the College Wonder. During the time that this work was being done, it was believed that oats may be continually improved by selections within a pure line.[2] In fact, the stability of a pure line was not generally known by most agroanomists until 1912. The theory of the day was also practiced by the writer until 1910 when the results of testing Prof. Jeffery's oats had shown the fact that selections within pure lines are without results. Also, during these years, it was found that when the progeny of different individual

[2] It was during these years that Johannsen of Denmark was doing his epoch making work on beans, which has now become renowned as "Johannsen's Nineteen Beans."

plants can be sown side by side, many of them are easily eliminated on observation. They have weak straw, or various characteristics indicating that they would produce unpractical commercial varieties if increased. The improvement of an old variety rests upon the isolation of its various strains and the increase of the best.

The value of the plant row series, as a means of determining yield is variously estimated by the different crops breeders in the various states. Whether the plant row series is accurate as a yield series or not, one thing is certain: any one who has had one of these series planted with frequent checks for comparison would have no doubt in his mind regarding the inferiority of certain strains. He would discard them on sight. The attitude that has been taken in this work is that the strains that appear to be equal or superior to the check are the only ones worthy of continuing. Others are easily eliminated in the 1-100 acre series that usually follows the plant-row test. By this means only promising strains enter the variety series.

PURE LINE WORK.

Beginning with 1906, a new method of breeding small grains has been in use. This plan consists of making large numbers of plant selections, from as many commercial varieties as were available, and to compare the selections with each other in a series of individual plats. The plant-row series with frequent checks is the most satisfactory form of the series.

Selections were made from five new sources in 1906, seventeen new sources in 1907, another seventeen sources in 1908, two new sources in 1909, and forty-eight new sources in 1910. Thus new sources of seed, coming from farmers' seedsmen, experiment stations and the U. S. Department of Agriculture (the latter collected from all oat growing countries from around the world) have been added to the list until now (1919), there are 150 numbers. Newly selectioned plants are added to the list annually, and tested out in plant-row series.

This has resulted in the elimination of many original sources of seed.[1] Others were represented by just one pure line apiece when they enter the variety series.

YIELD TESTING.

Twenty years ago the method of testing the yielding ability of varieties was very crude as we view it today. Usually the experimenter depended upon one plat to the variety, and he may, or may not, have had checks in the series. Perhaps he had a check on either side of the field and one in the center. These plats were so nearly square that it was not possible to duplicate results. The variation in soil between plats was usually greater than the variation among the yielding abilities of the varieties under test. Such work is of comparatively little value under Michigan conditions.

[1] The Big 4 Oats was discarded in 1908 after two years testing. Big 4 Oats had been received from two sources at that time. Long's White Tartar, Picketts' American Banner and Swedish Select, were also dropped in 1908. The Sixty Day Oats was dropped in 1911. In that year the Station had over two hundred pure lines of oats under test. These represented the choice of those that had been gathered during the years 1906 to 1911. The last strain of the following varieties were discarded in 1912: Tartar King, Minnesota No. 26, Progress, Joanette, Chinese, Garton No. 364, Garton No. 691, Clydesdale, S. P. I. No. 21,672, S. P. I. No. 22,005, S. P. I. No. 23,295, S. P. I. No. 24,846, S. P. I. No. 24,847, Wyoming, Spanish, White Hungarian, White Kirche, Anderbeck, Beseler II, Probestier, Beseler I, Beseler III, 6 varieties from Spain, Duppau, 4 varieties from Germany, Early Sensation, Fichtelbirge, Side Oats, and Black Oats.

Experience is a good teacher, and it seems that experimenters get their education that way. Especially is this true when science has not offered reliable methods. Thus the years of 1906 to 1913 were used in working out a reliable method of variety testing at the Michigan Station. Until 1911 the plant-row series with frequent checks was the most reliable plan that had been devised. In later tests of larger quantities, many experimenters would multiply the number of these rod rows scatter them among the others and depend upon the average of the results obtained to indicate the relative yield of varieties. This is known as a reduplication series. The difficulty that the Michigan Experiment Station has found (in this class of work) is that very small losses of grain in these plats upset the results and that the amount of labor necessary made the testing of large numbers of strains out of the question.

Fig. 1. A portion of the 1914 oat variety series. Each variety is planted in a long narrow strip. Each fifth plat (strip) is planted from the check or standard variety with which all of the other varieties are compared. Each plat is four drills wide and about 400 feet long. Two such plats can be planted at one trip of an eleven hoe drill, planting four hoes on either side and leaving three hoes vacant in the center for an alley. A thirty inch alley is allowed between the drill widths. The length of the plats should be at least twenty *times the distance* between the centers of the check plates, because of the soil variability, and to permit the calculation of a check yield for each and every plat of the series by interpolation between the yields of adjacent checks. This method (it will be noticed) combines the benefits *derived from two principles, viz., reduplication and checks. As each plat crosses a large* number of soil conditions, it is in reality a reduplication. The series are also duplicated annually.

Figure 1 illustrated the method of variety testing now in use. Each plat is a long narrow strip and therefore crosses a great variety of soil areas. it is as efficient as a reduplication series. It has the advantage, because the elements are end to end and can be cut collectively at one trip of the binder.[4] The shocks belonging to a plat are set up in a row and can easily be brought together at threshing time. The series are duplicated each year. The duplicate series usually follow each other.

After threshing the grain is recleaned in a fanning mill and weighed. The results are recorded in pounds per plat. In order to reduce these results to a uniform basis the corresponding yield of the standard or check variety is also calculated for every plat of the series. This calcula-

[4] The sum of the yields of the reduplication plats is found by means of the binder instead of by means of the adding machine.

tion is based upon the fact that the plats are about twenty times as long as the distance between checks, and therefore one is justified in assuming that the soil fertility varies continuously between checks.[5] The yield of the check plats are determined in the same manner as those for the other plats. The check-yields for the intervening plats are determined by proportion of distance to the difference between the yields of adjacent check plats. In the results that follow the figures in column P are the actual yields in pounds per plat for the varieties in question, and those in the column C are the calculated yields of the check variety for the same plats. In order to reduce this result to one figure, the yield is represented as a per cent of the yielding power of the check variety.[6] It is desirable to run the entire series twice each year, and take an average between the ($\frac{100P}{C}$) coefficients of yield obtained for the duplicate plats.

TABLE II. A PORTION OF THE OAT YIELDS 1911.

P—Actual yields in pounds per plat.
C—Calculated yield of check variety for each plat.

Strain No.	Variety.	One Series.			Duplicate Series.			Ave.
		P.	C.	100 P / C.	P.	C.	100 P / C.	100 P / C.
61601	Check (Alexander)	58.3	58.3	100.00	69.8	69.8	100.00	100.00
60401	American Banner	73.0	62.64	116.54	61.6	68.6	89.80	103.44
60501	American Banner	83.6	66.98	124.81	71.5	67.4	106.08	115.44
61201	College Wonder	92.7	71.32	129.98	66.0	66.2	99.70	114.84
61301	American Banner	84.5	75.66	111.68	71.5	65.0	110.00	110.84
61601	Check (Alexander)	80.0	80.00	100.00	63.8	63.8	100.00	100.00
61501	American Banner	85.8	81.94	104.71	66.5	63.36	104.96	104.83
62704	Worthy	78.6	83.88	93.71	64.0	62.92	101.72	97.71
62803	Joanette	35.2	85.82	41.02	39.0	62.48	62.42	51.72
70503	Golden Fleece	72.6	87.76	82.73	62.7	62.04	101.06	91.89
61601	*Check (Alexander)*	*89.7*	*89.70*	*100.00*	*61.6*	*61.60*	*100.00*	*100.00*
70806	Clydesdale	81.4	88.92	91.54	69.8	61.16	114.13	102.83
76003	Improved American	83.0	88.14	94.17	71.5	60.72	117.75	105.96
763001	Joanette	69.3	87.37	79.33	57.2	60.28	94.89	87.11
76803	Progress	65.4	86.58	75.54	54.5	59.84	91.08	83.31
61601	*Check (Alexander)*	*85.8*	*85.80*	*100.00*	*59.4*	*59.40*	*100.00*	*100.00*

Table I presents four checks and the plats between them in the order they were run in the 1911 variety series. It also gives the results of the duplicate portion of the series dealing with the same varieties. It is easily observed that the values of C vary from one check to the next according to distance and difference between the yield of adjacent checks (They are straight line interpolations between checks). The results of plant-row series are not expressable by this means, as their interpretation is largely observational. The small plats of earlier years were nearly all threshed with a flail. As losses are unavoidable by this means, the data are not reliable plat results. The 1910 series was planted by the edge of muck and certain areas lodged.

[5] Rarely there is a reason to think that the zigzag fluctuations of the check yields does not represent real variations in yield. In such cases a curve like $y—a+bx+cx^2$ is used for short distances.

[6] *This is known as the coefficient of yield and is determined by dividing the P by the* corresponding C, and multiplying by 100 to reduce to the form of per cent. If one wishes these results in bushels per acre, it is only necessary to determine (the 100%), a reliable figure for the standard variety in bushels per acre.

Table II gives the results of the larger oat plats for 1909 and 1910. The Alexander which yielded an average of 67.7 bushels per acre in 1910, on the college plats is used as 100%. Taking the average of the coefficients of yield for a variety it is easy to find the corresponding bushels per acre. From these results, it is observed that the Alexander (61,601) and Worthy (62,704) were the only varieties that yielded more than 67 bushels per acre.

TABLE II. OAT TESTS 1909 AND 1910.

BEFORE THE INTRODUCTION OF ALEXANDER AND WORTHY.

P. Actual pounds per plat. C. Yield of Alexander for same plats.

Strain No.	Variety.	1909.			1909.			1910.			1910.			Average.	
		P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	Ave. per cent.	Bus. per acre. Estimated.
60401	American Banner	60.5	71.9	84.1	77.0	81.8	94.2	63.0	65.4	96.3	68.0	71.6	95.0	92.40	62.6
60501	American Banner	61.0	72.8	83.8	......	......	......	64.0	67.8	94.4	71.0	74.2	95.7	91.30	61.8
60601	American Banner	63.0	73.6	85.6	82.0	81.8	100.2	62.0	70.2	88.3	68.0	76.8	88.5	90.65	61.4
61001	American Banner	61.0	74.4	82.0	75.0	77.7	96.5	63.0	72.6	86.8	67.5	79.4	85.0	87.57	59.3
61101	American Banner	69.0	76.0	90.8	52.0	73.7	70.5	60.0	75.9	79.0	57.5	81.2	70.8	77.77	52.7
61201	College Wonder	79.0	76.7	103.0	57.0	69.7	81.8	67.0	76.8	87.2	67.0	79.9	83.9	88.98	60.2
61301	American Banner	77.0	77.4	99.5	57.0	65.7	86.8	62.0	77.7	79.8	70.7	78.6	89.1	88.80	60.1
61401	American Banner	62.0	78.1	79.4	50.0	61.2	81.7	69.0	78.6	87.8	69.0	77.3	89.3	84.55	57.2
61501	American Banner	80.0	79.4	100.8	60.0	60.7	98.9	66.0	72.9	90.5	77.0	77.4	99.5	97.43	65.9
61601	Alexander	80.0	80.0	100.0	60.2	60.2	100.0	74.0	74.0	100.0	76.0	76.0	100.0	100.00	67.7
62703	Improved American	84.0	80.6	104.2	52.5	59.7	87.9	71.0	70.7	100.4	74.5	78.8	94.5	96.75	65.5
62704	Worthy	88.0	81.2	108.4	59.0	59.0	100.0	64.0	69.6	92.0	77.0	80.2	96.0	99.10	67.1
62803	*Joanette*	74.0	81.8	90.5	......	......	......	61.0	68.2	89.4	66.0	81.6	80.9	86.93	58.9
62804	Joanette	73.0	81.8	89.3	......	......	......	59.0	67.9	86.9	60.0	83.3	72.0	82.73	56.0
70402	Golden Fleece	......	......	......	......	......	......	48.0	67.6	71.0	61.0	83.6	73.0	72.00	48.7
70503	Golden Fleece	......	......	......	......	......	......	51.0	67.3	75.8	68.7	83.9	81.9	78.85	53.4
70706	Clydesdale	......	......	......	......	......	......	56.0	64.8	86.4	53.0	84.2	63.0	74.70	50.6
70806	Clydesdale	......	......	......	......	......	......	55.0	62.6	87.9	56.5	83.0	68.1	78.00	52.8
71208	American Banner	......	......	......	......	......	......	41.0	60.4	67.9	69.0	81.5	84.7	76.30	51.7
72102	Minnesota No. 26	......	......	......	......	......	......	38.5	58.2	66.2	48.7	80.0	60.9	63.55	43.0
74702	American Banner	......	......	......	......	......	......	46.5	58.6	79.4	56.5	78.5	72.0	75.70	51.2
74710	American Banner	......	......	......	......	......	......	46.0	61.2	75.2	54.5	70.5	77.3	76.25	51.6
76003	Improved American	......	......	......	......	......	......	56.0	63.8	87.8	70.0	64.0	109.3	98.55	66.7
76301	Joanette	......	......	......	......	......	......	47.5	66.4	71.5	53.0	57.5	92.2	81.85	55.4
76803	Progress	......	......	......	......	......	......	53.0	71.8	73.8	44.5	51.0	87.2	80.50	54.5

Because of the results these varieties were increased on the College farm and a bushel of each variety was distributed to farmers in 1911. The general distribution began in 1912, and during the next two years farmers generally reported the Alexander and Worthy as yielding ten bushels per acre more than their old varieties, when planted side by side.

Fig. 3. A field of Worthy Oats on the College farm (field No. 8) in the summer of 1912. It averaged seventy-five bushels per acre with the exception of a swale in the back of the field. This field attracted the attention of the passers that summer because of the evenness of the stand, and the way that the oats filled.

Over six thousand bushels of Worthy Oats were used for seed in 1915. If we consider that only one-fifth of the yield has been used for seed each year, at least 100,000 acres of them were grown in 1917. Exact figures are unobtainable because the spread has largely been from farm to farm, by natural processes. Their very stiff straw is an outstanding factor in in favor of these oats, especially on heavy land. They still retain their popularity and high yielding qualities, and are now (1918) so widely grown as to be known by most progressive Michigan farmers.

Since their introduction, the Alexander has been grown more extensively on sandy soil, and the Worthy on heavy land. This would result in reports favoring the Worthy on heavy soil. Be this as it may, we occasionally note instances like the following: Mr. Geo. Hurteau of Allegan has grown both Alexander and Worthy on his heavy low laying soil that before drainage was a cattle wallow, but now is one of the richest farms of that section. He has given up the Worthy in favor of the Alexander, which he says is yielding more bushels of grain for him.

IMPROVED METHODS OF TESTING VARIETIES.

During the years that the oat improvement work has been going on, methods of oat improvement and methods for testing varieties have also been under investigation. It is impossible to fully understand the one without the other. The methods have changed from year to year as greater light could be obtained on the subject.

A general view of the 1911 variety series is shown in figure four. It will be noticed that the plats were full drill widths (eleven hoes), at that time and that the plats were much shorter than now. That shape of plat was used during the years of 1909 to 1913. The duplicate series of 1911 were end to end and ran in reverse order. During recent years, the duplicate series have been parallel, i. e., a continuation of the same series. This permits the plats to be longer and narrower, bringing the check plats nearer together and making the determination of the check yields for the intervening plats more reliable. The best results are obtained when the length of the plats are about twenty times the distance between the centers of the check plats. The accuracy of the results are indicated by the nearness of the coefficients of yield representing the duplicate plats. They should usually be within 5% or more rarely within 10% of each

Fig. 4. Up to 1913, the plats were full drill width. Figure 4 shows a general view of the 1911 oat series. There were two series end to end that year, the plats only being about 300 feet long. That left the length of the plats about 14 times the distance between the centers of the check plats. This relation should be at least twenty times.

other. A difference of 15% or 20% means a mistake that is not due to the relationship of the plats if the plats are arranged as above. A patch of weeds, or imperfect planting in one of the duplicates may cause a difference of 30%. Shattering in spots if over-ripe, or lodging in small localities may create a large mistake. These mistakes also arise at harvesting and during threshing if more grain is lost from one plat than is lost from another. If the loss is equal from all the plats (checks and all), the results (coefficients of yield) are disturbed very little if at all.

In calculating, four place figures have usually been made use of, especially in the yield for the check variety on the intervening plats. These four place figures have been used in the calculation of the per cent or $\frac{100P}{C}$. Also averages are obtained with four place coefficients of yield. To save space the results are given in the tables as three place figures.

In all cases the yield is expressed as pound per plat for the variety under test, pounds per plat for the check variety on the same plat, and the per cent or coefficient of yield. In the final summations given in Table V the yields are expressed as percents of the yielding power of the check variety. An average is then taken of those of the various years. The 100% is obtained by taking an average of actual yields for the check variety during five years.

TABLE III. OAT YIELDS 1911-1914.

P. Actual results in pounds per plat. C. Calculated yield of check variety on same plats. Alexander used as check 100X.

Strain No.	Variety.	1911.			1911.			1912.			1913.			1914.			1914.		
		P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.
60401		61.6	68.6	89.8	73.0	62.6	116.5	89.7	94.2	95.3	91.8	83.6	109.8						
61201	College Wonder	66.0	66.2	99.7	92.3	71.3	130.0	112.0	92.9	120.6	91.2	83.6	109.1	80.8	61.8	130.7	70.0	60.8	115.1
61601	Alexander	63.8	63.8	100.0	80.0	80.0	100.0	95.5	95.5	100.0	83.5	83.5	100.0	59.4	59.4	100.0	59.5	59.5	100.0
62704	Worthy	64.0	62.9	101.7	78.6	83.9	93.7	85.4	91.6	93.2	95.3	83.7	113.9	66.2	64.3	103.0	65.1	62.1	104.9
76563	Fleece	62.7	62.0	101.1	72.6	87.8	82.7	95.6	90.3	105.8	83.9	83.7	100.2	81.4	66.7	122.0	69.7	63.3	110.0
76606		69.8	61.2	114.1	81.4	88.9	91.5	99.9	91.0	109.8	85.4	85.4	100.0	69.7	69.2	100.7	61.8	64.6	95.7
76003		71.5	60.7	117.7	83.0	88.1	94.2	80.1	92.9	86.2	78.6	87.0	90.3						
83301		60.5	62.3	97.2	79.7	83.8	95.1	80.1	103.5	77.4									
83503		11.5	11.0	104.5				71.0	102.0	69.6									
84303		59.4	68.0	87.4	62.7	79.9	78.51	67.8	100.5	67.4									
87101		75.9	70.8	107.1	82.5	77.9	105.9	66.7	94.8	70.4									
87303		81.4	74.9	108.7	78.8	75.1	102.2	83.8	96.7	86.7	76.4	88.6	86.2	72.3	69.5	103.9	63.5	63.9	99.3
87403		78.6	77.3	101.7	77.0	73.6	104.7	79.0	100.5	78.6	71.2	90.2	78.9						
87501		66.0	78.5	84.1				104.7	102.3	102.3	85.1	93.5	91.0						
87503	Garton 572	61.0	80.4	75.9	90.7	71.9	126.1	111.0	104.1	106.6	95.9	95.1	100.8	79.5	67.5	117.8	64.4	61.9	104.1
87702		66.5	81.7	81.4	72.6	71.7	101.3	88.0	101.1	87.2	93.6	96.7	96.8						
87704		74.8	82.3	86.8	69.8	71.6	97.5	92.9	98.7	94.1	84.2	98.3	85.7						
810005	Tartar	79.7	84.8	94.0	70.4	71.8	98.0	106.8	96.4	110.0	105.9	98.8	107.2	73.3	65.4	112.1	71.6	59.9	119.5
810012		80.8	86.5	93.4	65.4	72.1	90.7	104.1	94.1	110.7	101.7	97.5	104.3						
90402		35.7	35.8	99.8				74.7	91.8	81.3									
90502		33.0	36.4	90.8				67.8	91.9	73.7									
91101		34.6	36.7	94.3				80.6	92.1	87.6									
91301		30.2	36.0	83.9				83.3	99.0	84.1									
92204		34.6	37.5	92.2				88.6	92.2	96.1									
93006		33.0	38.6	85.6				61.9	91.6	67.6									
93201		32.0	39.9	80.2				53.4	90.9	58.7									
93505		29.1	31.8	91.6				87.0	90.3	96.4									
93904		28.0	31.4	89.1				89.7	97.0	92.5									
98203		29.1	31.6	92.2				86.5	96.5	89.6									
915103	Great Dakota	41.2	35.3	116.7				95.0	96.0	99.0	107.5	96.2	111.7	72.4	63.4	114.2	69.8	57.9	120.5
915302		39.6	37.2	106.3				93.9	92.4	101.6	101.0	95.0	106.3	77.6	61.6	126.0	66.6	56.8	117.3
915401		28.0	32.1	87.3				84.9	89.9	94.5									
915504		29.1	32.3	90.0				80.6	87.4	92.2									
916601		31.4	33.8	92.8				96.6	102.8	94.0									
915604	Danish Giant	33.0	33.1	99.8				105.7	103.7	101.9	66.0	68.3	99.6	60.4	61.8	97.7	65.4	57.7	113.4
08301	——	The 19	11 Plan	t-Row	Series	includ	ed 190	27.8	31.3	89.3	64.8	62.5	103.5						
08518		plats, o	f which	these	are the	superi	or ones	14.7	31.5	46.8	36.3	64.5	56.9						

TABLE III. OAT YIELDS 1911-1914.—*Concluded.*

Strain No.	Variety.	1911.			1911.			1913.			1913.			1914.			1914.		
		P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.	P.	C.	Per cent.
06402								34.2	30.6	111.5	82.3	66.4	124.0	76.7	62.1	123.5	71.8	58.6	122.6
06907								12.2	31.9	38.1									
06909								13.9	31.8	42.4	32.9	62.3	52.8						
06913								14.4	33.2	43.4	41.4	63.9	64.8						
015708								32.0	33.6	95.2	60.0	65.4	91.7	63.4	62.3	101.6	61.7	59.5	103.7
016002								33.1	34.0	97.3	67.0	67.0	100.0	65.8	62.1	105.9	64.0	60.3	106.1
016602								35.8	35.0	102.2	86.1	70.1	122.8	60.8	61.5	98.8	63.6	60.2	105.5
016901								34.7	33.9	102.2	88.7	71.7	123.7	69.7	61.0	113.7	63.4	60.1	105.4
016902								35.2	32.9	107.1	95.1	73.3	129.7	67.2	60.4	111.1	61.8	60.0	103.1
017001								27.8	31.6	87.3									
017002								32.8	30.3	107.3	90.3	74.9	120.6	58.3	60.0	97.1	57.9	59.6	97.2
017203								31.0	29.9	103.5	82.9	77.2	107.4	44.4	60.1	73.9	64.6	59.3	108.8
017301								28.3	29.5	96.0	85.0	78.1	108.8	64.0	60.1	106.4	54.3	59.0	92.0
017401								28.8	29.0	99.2	88.7	78.9	112.4	61.8	60.2	102.7	52.5	58.7	89.4
018202								26.7	29.0	92.0	63.2	79.7	79.3						
018504								28.3	29.4	96.2	77.6	83.1	93.4	61.0	60.1	101.4	64.0	57.5	111.4
018801								26.2	29.8	87.7									
018901								14.9	17.4	85.9									
019003								16.5	16.0	103.1	81.8	84.0	97.4	59.5	60.0	99.1	60.8	56.5	107.5
019201								12.8	16.7	76.8									
019203								12.8	19.8	64.9									
019303								14.9	21.6	69.6									
019403								11.2	23.2	48.3									
01606								35 plant rows in 1912									10.2	10.3	98.8
10702																	7.6	10.0	75.7
10705																	9.2	9.8	94.4
10801																	11.0	9.5	122.4
10803																	10.5	9.6	109.8
10804																	10.6	9.9	106.8
10805																	12.5	10.3	121.6
10808																	11.2	10.6	105.3
11004																	10.8	10.4	103.9
11005																	7.2	10.5	68.7
11007																	8.7	10.5	82.7
11008																	9.1	10.6	86.2

Ac 95		78.1	87.2	89.6				98.2	104.7	93.8									
Ac 96		80.3	89.5	89.7				96.1	105.6	91.0									
Ac 97		78.1	87.2	89.6				85.4	103.9	82.2									
Ac 98		86.3	84.9	101.6				90.7	101.3	89.5									
Ac 100		72.1	72.5	99.5				95.0	98.6	96.3	85.5	84.9	100.7						
Ac 101		78.6	72.8	108.0				89.7	96.0	93.5	74.9	85.8	87.3						
Ac 102		82.5	72.7	113.4				95.5	87.4	109.3	91.9	87.5	105.0						
Ac 104		75.3	72.4	104.1				92.8	81.4	113.3	71.2	88.4	80.5						
Ac 108								92.3	75.5	122.2	88.3	89.3	98.8						
Ac 113	Big Four							81.1	69.6	116.6	88.7	90.2	98.3	70.5	59.8	117.9	65.1	55.6	117.1
Ac 122	Stephens													62.7	59.7	105.1			
Ac 123	*Harvest Queen*													58.0	54.6	106.2			
Ac 124	Griffin													54.7	53.7	101.8			

Table III sets forth the results of variety testing during the years 1911 and 1914. Besides this there were one-hundred plant row plats in 1911 and thirty-five plant rows in 1912. It was not possible to run duplicate series in 1912 and 1913, because the land was not available, however, they compare fairly well with each other. The results of those years had brought the College Success into such prominence that it was used as a check during the years 1915 to 1917. The yields of College Success are as follows: 1912, 74.9 bushels; 1913, 64 bushels; 1914, 76.5 bushels; 1915, 89.0 bushels; and 1916, 51.4 bushels per acre, giving an average of 71.6 bushels per acre during 1912 to 1916 on the college plats. Table IV gives the results of the 1915 to 1917 test with College Success as a check, and Table V gives the results for the yield testing work during 1914 to 1917, arranging the varieties in order the of their relative yields. The average coefficients of yield and their equivalent bushels per acre are also based on College Success as 100% equaling 71.16 bushels per acre.

TABLE IV. YIELDS OF OAT VARIETIES.

College Success Used as Check.

P. Actual yield in pounds. C. Check yield of same plat.

Strain No.	Variety.	1915. P.	1915. C.	1915. Per cent.	1915. P.	1915. C.	1915. Per cent.	1916. P.	1916. C.	1916. Per cent.	1916. P.	1916. C.	1916. Per cent.	1917. P.	1917. C.	1917. Per cent.	1917. P.	1917. C.	1917. Per cent.
81201	College Wonder	104.5	104.9	99.7	96.5	98.5	98.0	57.8	39.4	146.8	86.7	63.8	135.9	29.0	34.3	84.6	38.0	39.5	96.2
91601	Alexander	91.5	104.2	87.8	95.5	98.5	97.0	55.0	42.6	129.3	83.4	63.2	132.0	31.6	34.2	92.4	35.0	39.0	89.7
63704	Worthy	88.5	103.1	85.9	91.5	96.3	95.0	46.9	45.7	102.6	76.5	62.6	122.2	27.2	34.2	79.7	38.0	38.5	98.7
70502	Fleece	97.5	102.6	95.1	99.5	94.2	105.7	57.5	49.8	115.5	72.1	61.6	117.1	31.0	35.1	88.3	39.0	38.2	102.2
87503	Garton 572	102.0	101.7	100.3	105.5	92.2	114.4	55.1	50.7	108.8	71.2	61.1	116.4	34.6	36.2	95.8	38.0	38.4	99.1
810006	Tartar	105.0	101.3	103.7	100.5	92.5	108.6	55.4	51.5	107.5	77.9	60.1	129.7	35.9	37.2	96.4	37.7	38.5	97.7
915103	Great Dakota	106.5	100.6	105.9	103.5	93.0	111.3	61.2	51.0	120.0	76.7	60.7	126.3	40.0	38.0	105.3	37.7	37.6	100.3
915302	Czar of Russia	106.5	100.3	106.1	107.5	93.2	115.3	66.7	49.6	134.6	79.7	59.8	133.3	38.0	37.8	100.6	39.3	36.5	107.6
915604	Danish Giant	93.0	99.9	93.1	93.0	94.2	98.8	52.1	48.1	108.2	58.5	59.6	98.2	......	......	......	......	......	......
96403	College Success	99.9	99.9	100.0	94.5	94.5	100.0	46.7	46.7	100.0	59.4	59.4	100.0	37.5	37.5	100.0	35.4	35.4	100.0
016002	Early Lincoln	86.5	99.8	86.7	99.0	94.8	104.4	60.6	48.1	144.6	86.9	59.2	146.7	34.9	37.5	93.1	36.2	35.4	102.2
9916302	Ligowo	91.0	99.7	91.3	83.5	96.3	86.7	56.8	49.6	114.6	64.0	59.2	108.2	39.0	37.7	103.3	35.8	34.6	103.7
016901	Lauterwits	92.0	99.7	92.3	96.5	97.2	99.3	49.1	51.0	96.3	58.9	59.1	99.7	37.5	38.1	98.2	38.4	34.8	110.4
018909	Lenterwits	73.0	99.8	73.2	99.5	97.8	101.7	52.6	50.4	104.3	71.7	59.1	121.3	29.6	38.6	76.9	34.0	35.1	97.0
017002	Comun	88.0	99.9	88.1	90.5	97.7	92.7	54.4	48.5	112.3	88.8	59.2	150.0	42.6	38.2	111.5	40.5	35.5	114.1
017208	Romanesi	70.0	100.3	69.8	82.0	95.5	85.9	44.1	46.5	94.9	58.4	59.3	98.5	......	......	......	......	......	......
017301	Spanish	96.0	100.6	95.5	92.0	93.5	98.4	49.7	44.5	111.7	58.0	59.7	97.2	......	......	......	......	......	......
017401	Early Spanish	83.0	101.2	82.0	91.5	93.3	98.0	56.0	44.5	125.8	68.1	60.0	113.6	......	......	......	......	......	......
19006	English Wonder	92.0	101.6	90.5	94.5	95.2	99.3	41.5	44.5	93.3	62.2	60.2	103.3	......	......	......	......	......	......
10606	Strabe	95.5	102.6	93.1	99.5	98.3	101.2	56.0	44.1	127.4	69.5	61.0	114.0	35.7	37.5	95.3	35.0	35.7	398.1
10705	Seedling	101.0	103.1	97.9	92.0	99.7	92.3	53.4	43.7	122.3	64.9	61.4	105.7	37.0	36.7	100.7	39.0	35.8	108.9
10601	Western	111.0	104.4	106.4	112.5	97.7	115.2	54.0	43.2	125.0	65.9	61.9	106.5	35.9	36.2	99.3	40.0	36.5	109.7
10603	Western	116.0	105.1	110.4	104.5	94.3	110.8	52.5	42.4	123.9	65.6	62.9	104.2	42.2	36.4	115.9	42.5	36.9	115.1
10605	Wolverine	108.5	106.6	101.8	114.5	90.2	127.0	58.1	42.0	138.5	69.7	63.6	109.7	43.8	36.6	119.9	44.0	37.4	117.7
11004	Clydesdale	101.5	107.4	94.5	108.0	89.3	120.9	53.5	42.7	125.3	66.5	64.2	103.6	34.3	37.2	92.2	38.0	37.6	101.0
26601	Rosman	106.0	107.7	98.4	100.0	91.2	109.7	51.5	46.7	110.2	52.5	47.0	111.7	29.0	37.7	77.0	40.8	37.4	109.0
25607	Rosman	92.5	109.3	84.6	106.5	93.8	113.5	46.6	45.4	102.8	44.7	46.0	97.2	31.6	38.1	82.8	37.6	37.2	101.1
40633	Chinese	......	......	......	......	......	......	25.7	20.7	124.0	......	......	......	34.6	38.7	89.5	39.0	40.0	97.5
40650	Chinese	......	......	......	......	......	......	26.4	24.2	109.0	......	......	......	41.4	38.8	106.7	46.0	43.0	107.0
41703	Rosman	......	......	......	......	......	......	26.4	24.3	108.5	......	......	......	39.8	38.9	102.4	50.0	46.0	108.7
418306	Alberta	......	......	......	......	......	......	50.2	41.8	120.1	......	......	......	37.8	39.4	95.9	48.4	49.5	97.9
113	Big Four	110.5	105.2	105.1	107.0	99.4	107.6	46.5	44.0	105.7	53.6	45.0	119.1	36.5	39.8	91.6	51.7	50.0	103.4
122	Stephens	107.0	103.8	103.0	104.0	102.4	101.6	52.7	43.2	122.0	52.5	44.4	118.3	39.9	40.3	99.1	56.5	50.5	110.9
123	Harvest Queen	100.0	103.0	97.1	99.5	105.0	94.8	52.2	43.8	119.3	56.0	44.8	125.1	38.3	41.4	92.4	42.0	47.9	87.7
124	Griffin	115.0	103.5	111.1	86.0	104.7	82.2	47.8	44.3	107.8	47.5	45.1	105.2	42.0	42.0	99.9	36.1	44.8	80.8
131	Purisco	96.0	97.2	98.8	......	......	......	47.9	44.8	106.9	48.7	45.8	106.3	43.2	42.7	101.2	39.1	41.6	94.0
132	Michigan Swedish	95.0	95.8	99.1	......	......	......	43.5	44.7	96.2	50.8	46.1	110.1	51.7	42.9	120.4	46.5	39.2	118.6
133	Ust Sysel	......	......	......	......	......	......	32.5	44.6	72.9	31.5	46.5	67.8	25.8	42.4	60.9	21.7	40.0	54.3
135	Sixty Day	......	......	......	......	......	......	......	......	......	......	......	......	24.5	34.4	71.3	29.0	40.0	72.5
137	Wisconsin I	......	......	......	......	......	......	......	......	......	......	......	......	36.0	42.0	85.8	41.5	40.7	102.0

TABLE V. OAT YIELDS 1914-1917.

Expressed as average coefficient of yield.

Arranged according to production.

College Success taken as 100% equals 71.16 bushels.

Strain.	Variety.	1914.	1915.	1916.	1917.	Average.	Estimated bushels per acre.
10805	Wolverine	98.82	114.38	124.09	118.82	114.03	81.14
915302	*Czar of Russia*	98.85	110.71	133.94	104.11	111.90	79.63
61201	College Wonder	99.89	98.81	141.33	90.40	107.61	76.58
10801	Western	99.44	110.76	115.73	104.51	107.61	76.58
915103	Great Dakota	95.36	108.57	123.17	102.78	107.47	76.48
10803	Western	89.26	110.59	114.06	115.54	107.36	76.40
132	Michigan Swedish	....	99.13	103.14	119.47	107.25	76.32
113	Early Lincoln	86.18	95.53	145.66	97.64	106.25	75.66
87503	Garton No. 572	90.18	107.34	112.61	97.44	101.89	72.50
70503	Fleece	94.24	100.36	116.29	95.22	101.53	72.25
131	Purisco	....	98.80	106.59	97.58	100.99	71.86
11004	Clydesdale	84.07	107.68	115.10	96.60	100.86	71.77
05402	*College Success*	100.00	100.00	100.00	100.00	100.00	71.16
61601	Alexander	81.27	92.37	130.61	91.08	98.83	70.33
10606	Strube	80.33	97.14	120.53	96.68	98.67	70.21
123	Harvest Queen	86.32	95.93	122.22	90.09	98.64	70.19
10705	Seedling	76.68	95.11	114.02	104.78	97.65	69.49
016901	*Leutorwitz*	89.05	95.81	98.00	104.29	96.79	68.88
916602	Ligowa	83.04	88.99	111.41	103.51	96.74	68.84
25601	Rossman	78.20	104.06	111.17	93.02	96.61	68.75
017401	Early Spanish	78.07	90.01	119.71	....	95.93	68.26
915604	Danish Giant	85.79	95.91	103.24	....	94.98	67.59
62704	Worthy	84.46	90.42	112.38	89.22	94.12	66.98
124	Griffin	82.75	96.64	106.54	90.33	94.07	66.94
017301	Spanish	80.61	96.93	104.43	....	93.99	66.88
016902	Leutorwitz	87.03	87.43	112.81	86.96	93.56	66.58
25607	Rossman	81.27	99.05	99.96	91.94	93.06	66.22
019003	English Wonder	83.96	94.91	98.26	....	92.38	65.74
135	*Sixty Day*	....	....	94.80	71.88	83.34	59.30
017203	Romanesi	74.25	77.83	96.68	....	82.92	59.00
133	Ust Syol	....	....	70.32	57.61	63.97	45.52

ELIMINATION OF VARIETIES.

A passing glance through the preceding tables will reveal the fact that varieties have been dropped as rapidly as the experimenter could be satisfied of their inferiority.[7]

Of the 140 lots of seed that have been received, only 31 of them were under test in 1917. There was no question about those that showed themselves inferior in the plant-row series. There is little question about the desirability of the lowest producers after one year's yield testing. A third set has been dropped after two years of yield testing. But when it comes to the better varieties, one needs at least three year's results for reliable figures on yielding ability. Four of the strains listed in Table V have been in the variety series for nine years, and all except four of them have been in the yield series at least four years.

[7] The last strain of the following varieties were dropped in 1913: Swedish Select, Minnesota No. 6, Kherson, Silver Mine, Improved Scotch, Tartarian, Sensation, Improved Banner, 2 side oat varieties, *Regenerated Swedish Select, Canadian Banner, Dodge,* Spanish Lincoln, *Mezdag, Bucnim, New* Johnson, Giant Ligowo, Johnson, Lawrence, and Jewett's Clydesdale.

The following varieties were discarded in 1914: Garton No. 436, Garton No. 396, S. P. I. No. 226,885, European Hulless, S. P. I. No. 25,749, and Steuben.

The following varieties were discarded in 1915: Henderson's Clydesdale, Harrison's, New Market, S. P. I. No. 25318, Great Mogul, Beardsless *Propsleir*, Golden Rain, *Victory*, White Ligowa, Vogel, Parsons, *and four varieties from* an Illinois Seed Company.

No further varieties were dropped from the variety series in 1916, and only four more in 1917, but most of those in Table V that have not been distributed were dropped in 1918. Those dropped in 1917 were: S. P. I. Nos. 25,591, 25,849, 25,850, and English Wonder.

Of these varieties the Alexander and Worthy were distributed to Michigan farmers in 1912, College Wonder in 1915, College Success in 1916, and the Wolverine in 1917.

Of the three varieties that were distributed since 1912, the College Wonder is the most generally grown and apparently is gaining in popularity. The indications are that it will follow the Worthy as a higher yielder.

The College Success is favored by the farmers of Ottawa and the neighboring counties, but has been generally reported inferior to Worthy in eastern Michigan. However, twenty acres in Huron county showed 95 bushels per acre in 1918. In some sections, farmers get a great variety of results from the College Success. At the College, these oats were later than the average. This factor has been more or less consistent with the variety over the State and under the general weather conditions of the past two years has been an undesirable characteristic.

The Wolverine was represented by only one farmer's field in 1917, and has been distributed generally in a small way in 1918. About 350 acres were grown this year. It is too early to estimate its value, but at the College it has produced about 20% or one fifth more oats than the Worthy during the past four years. It will undoubtedly prove to be a valuable addition to Michigan agriculture.

SUMMARY.

1. There are two equally important problems to be considered:
   (a) The best variety of oats to grow.
   (b) The best cultural method.

2. The soil and climatic conditions are so variable in Michigan as to demand special varieties for some environments, and to cause a standard variety grown in an adjacent field to produce different results.

3. Always test a new variety side by side with the old accepting the new variety only when proven superior.

4. The relative yield of varieties cannot be tested in separate fields. They must be tested under identical conditions, and in long narrow strips side by side.

5. The oat breeding work has been in progress since 1900.

6. The present writer took up the work in 1906, yearly making large numbers of plant selections from specially planted beds.

7. Variety testing work began with the new strains in 1909. The most reliable early work was in plant-row series with checks. The methods were greatly improved in larger plats after 1913.

8. As the results of early testing, the Alexander and Worthy (two new varieties) were distributed to farmers in 1912. Each of these originated in a selected individual plant of 1906.

9. Over six thousand bushels of Worthy Oats were used for seed in 1915, and now this variety of oats is so widely grown as to be known by most progressive Michigan farmers.

10. The investigations since 1912 have found a few strains that are yielding more than the Worthy. The College Wonder was distributed in 1915, the College Success in 1916, and the Wolverine in 1917. Based on Worthy as 100%, the following are the results:

Strain.	Variety.	1914.	1915.	1916.	1917.	Ave.
10805	Wolverine	117.00	126.50	110.46	133.17	121.78
61201	College Wonder	118.27	109.28	125.81	101.32	113.67
05402	College Success	118.40	110.60	89.02	112.08	107.53
61601	Alexander	96.22	102.16	116.26	102.08	104.18
62704	Worthy	100.00	100.00	100.00	100.00	100.00

11. These results indicate that the Alexander is producing a 4% higher yield than the Worthy, yet farmers have generally preferred the latter. As a rule, the Alexander has been grown more extensively on the lighter soils, though some people prefer Alexander for heavy soils.

12. The College Success, College Wonder, and Wolverine have not been in the hands of the farmers long enough to establish their relative value. Of these three, the College Wonder is the most widely grown and apparently is gaining in popularity. On an average, it has produced a 13.5% higher yield than the Worthy at College, and a 23.8% higher yield over the State.

13. The College Success is favored by the farmers of Ottawa and neighboring counties. This is a late variety and does well only where it has a long growing season.

14. The Wolverine has produced a 21.8% higher yield than the Worthy and it will undoubtedly prove a valuable addition to Michigan agriculture.

BULLETINS

OF THE

Agricultural College Experiment Station

ISSUED DURING THE

YEAR ENDING JUNE 30, 1919

COMMERCIAL FEEDING STUFFS

Bulletin No. 282

Andrew J. Patten, C. F. Barnum, E. F. Berger, T. E. Friedemann and P. O'Meara.

The present feeding stuffs law (Act 91, P. A. 1917) became operative April 1, 1918. As the full text of the act was printed in Bulletin No. 279 only the main provisions will be discussed. Copies of the law will be furnished upon request.

Label. Every lot or parcel of "commercial feeding stuffs" shall bear on the bags or tags attached thereto a statement certifying, 1st, the net weight of the contents of the package, lot, or parcel; 2nd, the name, brand or trademark; 3rd, the name and principal address of the manufacturer or person responsible for placing the commodity on the market; 4th, the minimum percentage of crude protein, the minimum percentage of crude fat and the maximum percentage of crude fibre; 5th, the specific name of each ingredient used in its manufacture.

Registration. All "commercial feeding stuffs" within the meaning of the act must be registered annually. To make the fiscal year concurrent with the calendar year the present license period was made to terminate December 31, 1918, with a fee of $15.00 for each brand registered. After this date the registrations must be made on or before January 1st each year or before the feed is placed on sale and the license fee will be $20.00 per brand as in previous years.

Samples not required. The forwarding of samples at the time of applying for license is not necessary except when requested by the administrative officer.

Registrations may be refused or cancelled. The administrative officer may refuse to license a brand if the name appears to be deceptive or misleading. He also has power to cancel a license if it appears, at any time, that any of the provisions of the law have been violated.

Materials exempt from license fee. Unmixed whole seeds and grains; unmixed meals made directly from the entire grains of corn, wheat, rye, barley, oats, buckwheat, flaxseed, kafir and milo; corn and oats feed made by grinding together the pure grains of corn and oats; wheat, rye and buckwheat brans or middlings when unmixed with other materials; whole hays, straws, ensilage and corn stover when unmixed with other materials and all materials containing 60 per cent or more of water.

The definitions adopted by the Association of Feed Control Officials will be considered official in Michigan, and it is expected that the manufacturers will adhere to them as closely as possible.

RULES.

The following rules were passed by the State Board of Agriculture at a meeting held March 20, 1918, in East Lansing, Michigan:

RULE No. 1. "*Wheat Bran* with Screenings not exceeding Mill Run" is interpreted as meaning bran to which has been added, by a separate process, the whole or a part of the screenings separated from the particular lot of wheat producing the bran. The screenings may or may not be reduced.

RULE No. 2. "*Wheat Middlings* with Screenings not exceeding Mill Run" is interpreted as meaning middlings to which has been added, by a separate process, the whole or a part of the screenings separated from the particular lot of wheat producing the middlings. The screenings may or may not be reduced.

RULE No. 3. "*Wheat Bran and Wheat Middlings*" when labelled as containing "Screenings not exceeding Mill Run" are considered to be "Commercial Feeding Stuffs" within the meaning of the law and subject to license. This rule shall take effect April 1st, 1918.

RULE No. 4. "*Statement of Guaranteed Analysis.* Section 2 of the Feeding Stuffs law is interpreted to mean that only the minimum guarantees for Protein and Fat and the maximum guarantee for crude fibre may be stated on the labels. The sliding guarantee is prohibited. This rule shall take effect April 1st, 1918."

POINTS OF INTEREST TO DEALERS

Represent only Reliable Firms and before purchasing feed for resale in Michigan, find out if the particular feed has been properly licensed by the manufacturer, broker, or party responsible for its shipment into the State. The State law has no jurisdiction over parties residing outside of the State and the only way they can be reached is through the U. S. Department of Agriculture for a violation of the Federal Food and Drugs Act. Failure to license a feed in Michigan would not be a violation of the Federal law and if properly tagged, shipment into the State cannot be prevented. The Michigan law becomes operative only when such feed is offered for sale within the State. Ignorance of the provisions of the law is not sufficient grounds for defense. When the inspectors find an unlicensed feed being offered for sale the dealer is given written notice and requested to discontinue the sale until the person or concern responsible for shipping the product into the State has complied with the requirements of the law. Dealers who continue to sell unlicensed feeds after due notice has been given will be held responsible and evidence of the violation of the feeding stuffs law will be submitted to the Prosecuting Attorney in the county wherein the violation occurs.

Frequently it occurs that carload shipments reach their destination untagged. In such cases the dealer should telephone or telegraph the manufacturer or jobber immediately for proper tags and insist upon getting them at once as the sale of untagged feeds is not permissible under any circumstances. Tags sent forward by mail or placed in a carload of feed but not attached to the bags should be put on as the car

is unloaded. Some responsible person should give the matter of proper tagging careful attention rather than trust it to some irresponsible laborer.

Retain Freight Bills. The State inspectors of feeding stuffs are also federal inspectors and authorized to take samples of shipments made in violation of the Federal Food and Drugs Act. In order to establish evidence of interstate shipment it is necessary to secure copies of the freight bill, bill of lading and bill of sale covering a shipment. Dealers should, therefore, keep on file all the documents and papers relating in any way to all interstate shipments of feed stuffs.

POINTS OF INTEREST TO PURCHASERS.

Consult the annual bulletin and find out what companies are most consistently meeting their guarantees.

Do not buy a feed simply because it is cheap without comparing the guaranteed analysis with that of other feeds that may be available and also examine it carefully to determine, if possible, the ingredients of which it is composed. In these times of high prices, one should consider these points carefully.

Do not send samples for analysis without first writing for instructions on how to secure a representative sample. A sample from one bag or a small handful taken from the top of several bags is not representative and an analysis of such a sample would be of no value. The cost of making an analysis is considerable and we cannot take the time to analyze samples that are not representative of the lot from which they were taken. Our inspectors are continually collecting samples of feeding stuffs and in many cases we can furnish information concerning a particular brand of feed without making another analysis.

When purchasing feed in car lots, an inspector will be sent to draw samples if the office of the chemist in charge is notified upon arrival of the car.

Do not accept feed in untagged or unlabeled bags except such feeds as are exempt from license as heretofore mentioned. An untagged package gives the purchaser no guarantee as to analysis or ingredients and furthermore the product is sold in violation of the feeding stuffs law. Such cases should be brought to the attention of the office of the chemist.

If buying bulk feeds subject to license demand of the seller a printed guarantee giving the analysis and ingredient—the law provides that the purchaser shall have it.

COOPERATION WITH U. S. DEPARTMENT OF AGRICULTURE.

Through a plan of cooperation devised by the U. S. Department of Agriculture the State inspectors are empowered to collect samples from interstate shipment of feed stuffs found in Michigan under the Food & Drugs Act. In this cooperative work twenty-four cases were referred to the laboratory of the central inspection district in Chicago; eighteen of the samples were collected on account of deficiencies in protein, four were untagged shipments and two were taken at the suggestion of the Chief Inspector of the central inspection district.

REBATES.

The State law does not provide for the payment of rebates on feeds found deficient in some respect but such cases are often referred to this department. Settlement is advised on the basis of the combined protein and fat. The following example is taken from the present year's records.

Guaranteed (Protein, Fat) — Found (Protein, Fat) — Price per ton — Rebate per ton

$$\frac{(41 + 6) - (38 + 6.2)}{(41 + 6)} \times \$54.00 = \$3.21$$

(Denominator: Guaranteed Protein + Fat)

As the records of the distribution of rebates made during the year are not complete at this time no tabulation is made.

DEFINITIONS.

The following definitions of Feeding Stuffs and by-products used for feeding purposes have been adopted by the Association of Feed Control Officials of the United States at their several meetings, and, in the interest of uniformity, it is urged that all manufacturers and millers adhere to them as closely as possible in labeling the feeds intended for sale in Michigan.

Meal is the clean, sound, ground product of the entire grain, cereal or seed which it purports to represent.

Chop is a ground or chopped feed composed of one or more different cereals or by-products thereof. If it bears a name descriptive of the kind of cereals, it must be made exclusively of the entire grains of those cereals.

Screenings are the smaller imperfect grains, weed seeds and other foreign material having feeding value, separated in cleaning the grain.

Alfalfa Meal is the entire alfalfa hay ground, and does not contain an admixture of ground alfalfa straw or other foreign materials.

ANIMAL PRODUCTS.

Blood Meal is ground dried blood.

Cracklings are the residue after partially extracting the fats and oils from the animal tissue. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

Digester Tankage is the residue from animal tissue exclusive of hoof and horn, specially prepared for feeding purposes by tanking under live steam, drying under high heat, and suitable grinding. If it contains more than 10 per cent of phosphoric acid (P_2O_5), it must be designated Digester Meat and Bone Tankage.

Meat Scrap and Meat Meal are the ground residues from animal tissue exclusive of hoof and horn. If they contain more than 10 per cent of phosphoric acid (P_2O_5), they must be designated Meat and Bone Scrap, and Meat and Bone Meal. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

BREWERS' AND DISTILLERS' PRODUCTS.

Brewers' Dried Grains are the properly dried residue from cereals obtained in the manufacture of beer.

Distillers' Dried Grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation indicating the cereal predominating.

Malt Sprouts are the sprouts of the barley grain. If the sprouts are derived from any other malted cereal, the source must be designated.

BUCKWHEAT PRODUCTS.

Buckwheat Shorts or Buckwheat Middlings are that portion of the buckwheat grain immediately inside of the hull after separation from the flour.

CORN PRODUCTS.

Corn Bran is the outer coating of the corn kernel.

Corn Germ Meal is a product in the manufacture of starch, glucose *and other corn products and is the germ layer from which a part of the* corn oil has been extracted.

Grits are the hard, flinty portions of Indian corn, without hulls and germ.

Corn Gluten Meal is that part of commercial shelled corn that remains after the separation of the larger part of the starch, the germ and the bran, by the processes employed in the manufacture of cornstarch and glucose. *It may or may not contain corn solubles.*

Corn Gluten Feed is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germ by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn solubles.

OIL CAKE.

Oil Cake is the residual cake obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "oil cake" shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product, the name of the seed from which it is obtained shall be prefixed to "oil cake."

Ground Oil Cake is the product obtained by grinding oil cake. When *used alone, the term "ground oil cake" shall be understood to designate* the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "ground oil cake."

COTTONSEED PRODUCTS.

Cottonseed Meal is a product of the cottonseed only, composed principally *of the kernel with such portion of the hull as is necessary in the*

manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 per cent of protein.

Choice Cottonseed Meal must be finely ground, not necessarily bolted, perfectly sound and sweet in odor, yellow, free from excess of lint and must contain at least 41 per cent of protein.

Prime Cottonseed Meal must be finely ground, not necessarily bolted, of sweet color, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 per cent of protein.

Good Cottonseed Meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 per cent of protein.

Cottonseed Feed is a mixture of cottonseed meal and cottonseed hulls containing less than 36 per cent of protein.

Cold Pressed Cottonseed is the product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire cottonseed less the oil extracted.

Ground Cold Pressed Cottonseed is the ground product resulting from subjecting the whole undercorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire ground cottonseed less the oil extracted.

LINSEED AND FLAX PRODUCTS.

Flax Plant By-Product is that portion of the flax plant remaining after the separation of the seed, the bast fiber and a portion of the shives, and consists of flax shives, flax pods, broken and immature flax seeds and the cortical tissue of the stem.

Unscreened Flaxseed Oil Feed is the ground product obtained after extraction of part of the oil from unscreened flaxseed by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents. When sold without grinding the unground product shall be designated as "unscreened flaxseed oil feed cake."

Ingredients of Unscreened Flaxseed Oil Feed—Ground cake from partially extracted flaxseed and foreign seeds (wheat, wild buckwheat, pigeon grass, wild mustard, etc.).

Screenings Oil Feed is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from the smaller imperfect grains, weed seeds and other foreign materials having feeding value separated in cleaning the grain. The name of the grain from which the screenings are separated shall be prefixed to "screenings oil feed."

OAT PRODUCTS.

Oat Groats are the kernels of the oat berry.

Oat Hulls are the outer chaffy coverings of the oat grain.

Oat Middlings are the floury portion of the oat groat obtained in the milling of rolled oats.

Oat Shorts are the covering of the oat grain lying immediately inside the hull, being a fuzzy material carrying with it considerable portions of the fine floury part of the groat obtained in the milling of rolled oats.

Clipped Oat By-Product is the resultant by-product obtained in the manufacture of clipped oats. It may contain light, chaffy material broken from the ends of the hulls, empty hulls, light, immature oats and dust. It must not contain an excessive amount of oat hulls.

PEANUT PRODUCTS.

Peanut Oil Cake is the residue after the extraction of part of the oil by pressure or solvents from peanut kernels.

Peanut Oil Meal is the ground residue after the extraction of part of the oil from peanut kernels.

Unhulled Peanut Oil Feed is the ground residue obtained after extraction of part of the oil from whole peanuts, and the ingredients shall be designated as "peanut meal and hulls."

RICE PRODUCTS.

Rice Bran is the cuticle beneath the hull.

Rice Hulls are the outer chaffy coverings of the rice grain.

Rice Polish is the finely powdered material obtained in polishing the kernel.

WHEAT PRODUCTS.

Wheat Bran is the coarse outer coatings of the wheat berry obtained in the usual commercial milling process from wheat that has been cleaned and scoured.

Shorts or Standard Middlings are the fine particles of the outer and inner bran separated from bran and white middlings.

Wheat White Middlings or White Middlings are that part of the offal of wheat intermediate between shorts or standard middlings and red dog.

Shipstuff or Wheat Mixed Feed is a mixture of the products other than the flour obtained from the milling of the wheat berry.

Red Dog is a low grade wheat flour containing the finer particles of bran.

Wheat Bran with Mill Run Screenings is pure wheat bran plus the screenings which were separated from the wheat used in preparing said bran.

Wheat Bran with Screenings not Exceeding Mill Run is either wheat bran with the whole mill run of screenings or wheat bran with a portion of the mill run of screenings, provided that such portion is not an inferior portion thereof.

MISCELLANEOUS PRODUCTS.

Yeast or Vinegar Dried Grains are the properly dried residue from the mixture of cereals, malt and malt sprouts (sometimes cottonseed meal) obtained in the manufacture of yeast or vinegar and consists of corn or corn and rye from which most of the starch has been extracted, together with malt added during the manufacturing process to change the starch to sugars, and malt sprouts (sometimes cottonseed meal) added during the manufacturing process to aid in filtering the residue from the wort and serve as a source of food supply for the yeast.

Palm Kernel Oil Meal is the ground residue from the extraction of part of the oil by pressure or solvents from the kernel of the fruit of the Elaeis guineensis of Elaeis malanococca.

Ivory Nut Meal is ground ivory nuts.

TENTATIVE DEFINITIONS.

Corn Feed Meal is the by-product obtained in the manufacture of cracked corn, with or without aspiration products added to the siftings, and is the by-product obtained in the manufacture of table meal from the whole grain by the non-degerminating process.

Hominy Feed, Hominy Meal or Hominy Chop is a kiln-dried mixture of the mill run bran coating, the mill run germ, with or without a partial extraction of the oil and a part of the starchy portion of the white corn kernel obtained in the manufacture of hominy, hominy grits and corn meal by the degerminating process.

Yellow Hominy Feed, Yellow Hominy Meal or Yellow Hominy Chop is a kiln-dried mixture of the mill run bran coating, the mill run germ, with or without a partial extraction of the oil and a part of the starchy portion of the yellow corn kernel obtained in the manufacture of yellow hominy grits and yellow corn meal by the degerminating process.

Linseed Meal is the ground product obtained after extraction of part of the oil from ground flaxseed screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes, provided that the final product shall not contain over 6 per cent of weed seeds and other foreign materials and provided further that no portion of the stated 6 per cent of weed seeds and other foreign materials shall be deliberately added.

Oil Meal is the ground product obtained after the extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from seeds which have been screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "Oil Meal" shall be understood to designate linseed meal as defined. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to the words "oil meal."

Old Process Oil Meal is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term "Old Process Oil Meal" shall be understood to designate linseed meal as defined, made by the old process. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "old process oil meal."

New Process Oil Meal is the ground product obtained after extraction of part of the oil by crushing, heating and the use of solvents from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone "New Process Oil Meal" shall be understood to designate linseed meal as defined, made by the new process. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to "new process oil meal."

Ground Flaxseed or *Flaxseed Meal* is the product obtained by grinding flaxseed which has been screened and cleaned of weed seeds and other foreign material by the most improved commercial processes, provided that the final products shall not contain over 4 per cent of weed seeds and other foreign materials, and provided further that no portion of the stated 4 per cent of weed seeds and other foreign materials shall be deliberately added.

PROPOSED DEFINITIONS.

Wheat Bran consists of the coarse outer coatings of the kernel obtained in the usual commercial process of milling from wheat that has been cleaned and scoured.

Wheat Shorts or *Middlings.*

(a) Brown (Red) Shorts consist mostly of the fine particles of bran and germ and contains very little of fibrous offal obtained from the "tail of the mill."

(b) Standard (Total or Gray) Shorts consist of the fine particles of the outer bran, the inner or "Bee-wing" bran, germ, and the offal, or fibrous material, obtained in the last reduction on millings.

(c) White Shorts consist of a smaller portion of the fine bran particles and germ and a much greater portion of the fibrous offal from the "tail of the mill."

Red Dog consists of a mixture of low-grade flour, fine particles of bran and the fibrous offal from the "tail of the mill."

Ship Stuff (Wheat Mixed Feed) consists of pure wheat bran and standard, or total, shorts combined in the proportions obtained in the usual process of commercial milling.

(*Note—If to any of the foregoing brands of feed there should be added screenings, or scourings,* as hereinafter defined, either ground or unground, bolted or unbolted, such brand will be so registered, labeled and sold as clearly to indicate this fact. The word "Screenings" or "Scourings" as the case may be, shall appear as a part of the name or brand and shall be printed in the same size and face of type as the remainder of the brand name.)

Screenings consist of the smaller, imperfect grains, weed seeds, and other foreign materials, having feed value, separated in cleaning the grain.

Scourings consist of such portions of the cuticle, brush, white caps, dust smut, and other materials as are separated from the grain in the usual commercial process of scouring.

DISCUSSIONS OF RESULTS.

During the past year 919 samples of feed have been analyzed. Of this number 13 represented products which are not subject to license and 10 samples represented shipments which the manufacturers refused to license. In the future all unlicensed "commercial feeding stuffs" will be removed from sale wherever found. Dealers are, therefore, cautioned about handling such feed.

In summarizing the results of the inspection during the past year, we find that 75 or 8.3 per cent of the samples were below guarantee in

protein, 68 or 7.5 per cent were below guarantee in fat and 117 or 12.8 per cent were above guarantee in crude fiber. This is an improvement over the results obtained last year and nearly 50 per cent better than the results of 1916. The greatest improvement is noticed in the cottonseed meals. During the first year (1916) 51 per cent of the cottonseed meals examined were found below guarantee in protein. During the past year only 17 per cent of the cottonseed meal samples were deficient in protein. This is due, not so much to an improvement in the quality of the meal as to a more truthful statement of the guarantees. In other words, the cottonseed sold in Michigan during the past year has been no better than that of other years but the guarantees have been adjusted to fit the facts.

There has been a decided falling off in the number of samples of distillers and brewers grains shipped into the State. This is evidently due, in part, to a partial boycott on the part of distillers and brewers against shipping their products into dry states.

The highest percentage of deficiencies was found in the calf meals, hog meals and molasses feeds. In buying these classes of feeds the purchaser takes greater chances of not getting the value guaranteed than in any other classes of feed.

There has been a notable decrease in the number of samples of wheat bran and middlings on the market. These have been replaced in part by rye and barley feeds and other less common products.

A complete summary of the results obtained during the past three years is given in the following table. The figures here presented clearly show the effect of a vigorous inspection service in improving the whole feed situation throughout the State.

Feeds.	Number of samples.			Deficient in protein or fat.						Deficient in protein						Deficient in fat.						Excess of fibre.					
	1916.	1917.	1918.	1916.		1917.		1918.		1916.		1917.		1918.		1916.		1917.		1918.		1916.		1917.		1918.	
				No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cottonseed Meal	144	93	106	76	53.0	34	36.6	18	17.0	75	51.0	32	34.4	18	17.0	9	6.2	7	7.5	0	0.0	57	39.6	45	48.4	23	21.7
Cottonseed Feed	1	1	8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0
Linseed Meal	46	52	53	2	4.3	0	0.0	5	9.4	2	4.3	0	0.0	5	9.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	1.9
Distillers Grains, Corn	17	10	4	5	29.4	4	40.0	0	0.0	5	29.4	2	20.0	0	0.0	5	29.4	3	30.0	0	0.0	1	5.9	0	0.0	1	25.0
Distillers Grains, Rye	2	5	.....	2	100.0	5	100.0	.....	.....	2	100.0	3	60.0	.....	.....	2	100.0	5	100.0	.....	.....	1	50.0	3	60.0	.....	.....
Brewers Grains	8	10	1	1	12.5	2	20.0	1	100.0	0	0.0	2	20.0	0	0.0	1	12.5	2	20.0	1	100.0	1	12.5	1	10.0	1	100.0
Yeast & Vinegar grains	.....	.....	13	.....	.....	.....	.....	4	30.8	.....	.....	.....	.....	2	15.4	.....	.....	.....	.....	4	30.8	.....	.....	.....	.....	1	7.7
Corn Gluten Feed	24	17	15	4	16.7	2	11.8	1	6.7	1	4.2	1	5.9	0	0.0	3	12.6	1	5.9	1	6.7	1	4.2	0	0.0	0	0.0
Corn Gluten Meal	3	.....	1	1	33.3	.....	.....	0	0.0	0	0.0	.....	.....	0	0.0	1	33.3	.....	.....	0	0.0	0	0.0	.....	.....	0	0.0
Hominy Feed	10	5	7	4	40.0	0	0.0	1	14.3	2	20.0	0	0.0	0	0.0	4	40.0	0	0.0	1	14.3	0	0.0	0	0.0	0	0.0
Corn Oil Cake Meal	.....	.....	8	.....	.....	.....	.....	3	37.5	.....	.....	.....	.....	2	25.0	.....	.....	.....	.....	1	12.5	.....	.....	.....	.....	0	0.0
Corn Feed Meal	16	11	16	5	31.3	3	27.3	4	25.0	4	25.0	0	0.0	0	0.0	4	25.0	3	27.3	4	25.0	0	0.0	0	0.0	1	6.7
Animal By Products	16	29	27	4	25.0	7	24.1	3	11.1	2	12.5	4	13.8	1	3.7	2	12.5	4	13.8	2	7.4	1	6.7	4	13.8	4	14.8
Alfalfa Meal	9	7	10	0	0.0	0	0.0	1	10.0	0	0.0	0	0.0	1	10.0	0	0.0	0	0.0	0	0.0	2	22.2	0	0.0	0	0.0
Calf Meal	21	23	19	7	33.3	11	47.8	9	47.4	4	19.0	7	30.4	5	26.3	2	9.5	6	26.1	6	31.6	2	9.5	4	17.4	5	26.3
Hog Meals	12	10	21	6	50.0	7	70.0	5	23.8	0	0.0	3	30.0	3	14.3	6	50.0	5	50.0	4	19.4	1	8.3	5	50.0	6	28.6
Dairy & Stock Feeds	99	89	113	19	19.2	20	22.5	28	24.8	13	13.1	14	15.7	8	7.1	10	10.1	5	5.6	23	20.3	12	12.1	33	37.1	18	15.9
Molasses Dairy and Stock Feeds	*	60	77	*	*	12	20.0	23	29.8	*	*	12	20.0	15	19.5	*	*	3	5.0	10	13.0	*	*	16	26.7	27	35.1
Horse Feeds	75	4	17	10	13.3	0	0.0	2	11.8	1	1.3	0	0.0	0	0.0	9	12.0	0	0.0	2	11.8	9	12.0	0	0.0	4	23.6
Molasses Horse Feeds	*	68	44	*	*	2	2.9	0	0.0	*	*	0	0.0	0	0.0	*	*	2	2.9	0	0.0	*	*	4	5.9	9	20.5
Poultry Feeds	212	207	192	21	9.9	13	6.3	14	7.3	8	3.8	6	2.9	13	6.8	19	9.0	8	3.9	4	2.8	4	1.9	6	2.9	6	3.1
Corn & Oat Feeds	24	31	11	14	58.3	10	32.3	0	0.0	2	8.3	6	19.4	0	0.0	13	54.2	9	29.0	0	0.0	0	0.0	0	0.0	2	18.1
Wheat Bran	111	39	49	25	22.6	0	0.0	1	2.0	24	21.6	0	0.0	0	0.0	7	6.3	0	0.0	1	2.0	2	1.8	0	0.0	2	4.1
Wheat Middlings	109	42	48	17	15.6	0	0.0	3	6.2	10	9.2	0	0.0	1	2.1	10	9.2	0	0.0	2	4.2	2	1.8	0	0.0	1	2.1
Wheat Mixed Feeds	11	6	5	6	54.5	0	0.0	0	0.0	2	18.8	0	0.0	0	0.0	5	45.5	0	0.0	0	0.0	4	36.4	0	0.0	0	0.0
Wheat & Rye Mixed Feeds	2	6	5	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	1	20.0
Rye Feeds	3	.....	5	0	0.0	.....	.....	0	0.0	0	0.0	.....	.....	0	0.0	0	0.0	.....	.....	0	0.0	0	0.0	.....	.....	0	0.0
Barley Feed	2	2	5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Cereal Food By-Products	25	9	13	5	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	20.0	0	0.0	0	0.0	1	4.0	0	0.0	3	23.1

*Number of Molasses Feeds included in Dairy and Horse Feeds.

NEW FEEDS.

The demand for wheat flour substitutes has brought upon the market in abundance several feeds which heretofore were found but infrequently and only in small lots. Until recently these by-product feeds were usually worked up in ready mixed feeds, now, however, they are on sale as separate and distinct articles of feed. The more important of these are, barley feed, corn feed meal, oat meal mill by-products (oat hulls, oat shorts and oat middlings) and clipped oat by-product.

Barley feed is the by-product from the manufacture of pearl barley and barley flour and consists of the coarse hull and fibrous material surrounding the starchy kernel with some adhering fine particles thereof. This feed is light and bulky, having a high fiber content. The average of samples analyzed during the year follows: moisture, 9.0%; protein 9.2%; fat, 2.5% and crude fiber, 20.2%. On account of the bulkiness and fibrous quality of this feed it is not successfully fed alone but it does make a valuable addition to mixtures of heavy and compact feeds such as corn feed meal, cottonseed meal and other concentrates of similar character.

The origin and character of the various *oat by-products* is covered on a previous page under "definitions." The variation in feeding value of these products is wide and hence each lot should be bought only upon the basis of the guaranteed analysis. The fiber content of the oat products sold separately or mixed is an indication of the quality of any particular lot in question, the fiber content of the middlings being 4.6% while that of the hulls is 29.2%:—in other words, a high percentage of fiber indicates a large proportion of hulls and a correspondingly low feeding value. These feeds have a value similar to barley feed as regards making the grain ration more bulky.

Corn feed meal is a by-product obtained in the manufacture of cracked corn, table meal and corn flour. In feeding value, it is nearly if not quite equal to the entire grain and at times can be purchased for less per ton. In mixing rations for cows and horses, corn feed meal can be used in place of the whole corn meal with little depression of the food value. For feeding pigs the meal should be moistened as otherwise it will be rooted out of the troughs and wasted.

Corn bran is also derived from the manufacture of table meal and cracked corn and consists of the transparent outer layer of the kernel with particles of the starchy portion adhering; frequently light shrunken kernels and other chaffy materials are present. This product contains from 9 to 12% crude protein, 6 to 8% fat and approximately 10% fiber. Henry and Morrison give the total digestible nutrients as 73.1 pounds per 100 pounds of the feed. The light, flaky character of corn bran, gives it especial value for mixing with heavy, compact concentrates. Some manufacturers grind the bran while others put it on the market as it comes from the mill.

The extensive use of corn oil for cooking purposes has brought *corn oil cake meal* on the market in appreciable quantities. It is a valuable feed for dairy cows and is also in high favor with many hog growers. This feed is usually prepared for pigs by soaking a few hours and is

frequently mixed with middlings, which have about the same food value, at the time of feeding.

At several points in the State feeders have used velvet bean feed during the past winter with good results. The pods and seeds of the velvet bean are ground together without threshing, the product analyzing approximately 12.3% moisture, 17.1% protein, 4.6% fat and 14.3% fiber. In trials made by the Department of Animal Husbandry of the college it was found that the material was not palatable to swine and also contained too much fiber for these animals. Although meal made by grinding the seed alone gave somewhat better success it is used to best advantage as a hog feed only after cooking. Sheep ate the unground pods and seeds with relish and lamb feeders are getting good results by mixing the ground feed with shelled corn. When feeding this material to cattle it should be borne in mind that beans of any sort are not greatly relished and care should be taken not to include too great a proportion of the velvet bean feed in the grain ration. A small amount should be fed at first, increasing the proportion as the animals become more accustomed to it. Results obtained in the use of this feed in dairy rations as well as a corn supplement in rations for fattening steers are very favorable and indicate that it is worthy the attention of Michigan feeders.

A mixture of the bran and middlings obtained in the milling of rye for flour is sold as rye feed; this has about the same feeding value as the corresponding wheat mixed feed. There is greater danger of causing digestive disturbances in feeding rye products alone than with wheat products but limited amounts used in mixtures give good results. The cost to the feeder is usually somewhat lower than the cost of wheat feeds although the feeding value is approximately the same.

As a suggestion to the reader a few concentrated rations for dairy cows, using the feeds mentioned above, are given. These mixtures are in combinations to balance a roughage ration of clover hay and corn ensilage fed at the rate of 1 pound hay and 3 pounds ensilage per 100 pounds live weight with 1 pounds of concentrates per day for each 3 pounds or 4 pounds of milk given per day. In these mixtures as outlined certain substitutions can be made without greatly changing the nutritive ratio:—bran may be substituted for barley feed, hominy feed for corn feed meal, standard middlings for velvet bean feed meal, and corn oil cake meal for standard middlings and velvet bean feed meal by putting in a few pounds less than is indicated for the latter feeds mentioned. Rye middlings, rye bran or rye feed may be substituted for the corresponding wheat feeds.

1.

Barley feed	100 lbs.
Cottonseed Meal	50 lbs.
Corn Feed Meal	100 lbs.
Wheat Bran	100 lbs.

2.

Barley Feed	150 lbs.
Corn Feed Meal	100 lbs.
Cottonseed Meal	50 lbs.
Oil Meal	50 lbs.

3.

Barley Feed	100 lbs.
Gluten Feed	100 lbs.
Corn Feed Meal	100 lbs.
Cottonseed Meal	50 lbs.

4.

Velvet Bean Feed	100 lbs.
Wheat Bran	100 lbs.
Corn Feed Meal	200 lbs.
Cottonseed Meal	50 lbs.
Glutten Feed	50 lbs.

5.

Velvet Bean Feed.....	100 lbs.
Standard Wheat Middlings.............	100 lbs.
Barley Feed.........	100 lbs.
Hominy Feed.........	100 lbs.
Cottonseed Meal.....	50 lbs.

6.

Velvet Bean Feed.....	100 lbs.
Ground Corn........	100 lbs.
Ground Oats.........	100 lbs.
Cottonseed Meal......	50 lbs.

KEYSTONE STOCK CONDITIONER.

Since the last bulletin was issued, Keystone Stock Conditioner, mentioned therein has again been shipped into the State at a few points by the manufacturers, The Guaranty Food Co., Lewisburg, Pa. The analysis of this mixture reported last year gave the composition as largely cocoa shells and epsom salts; since that time sulphur, copperas, foenugreek, ginger, gentian, and capsicum have been added, but in such very small quantities that its conditioning value is practically unchanged. As noted in the previous bulletin no food value is claimed for this product and hence no action can be taken under the State feeding stuffs law.

CONDIMENTAL FEEDS.

Regarding condimental feeds as a whole it is very true that they combine low quality and high prices to an unusual degree. For the purpose of comparison, the cost of a tonic with linseed meal as a filler was computed, using retail drug prices, the cost was found to be 7 cents per pound. By replacing the linseed meal with cocoa shells the cost could be lowered to 5.7 cents per pound. The prices charged for stock "foods" range from 10 to 25 cents per pound. That purchasers pay the manufacturer a handsome profit is very evident.

The large majority of properly conducted experiments fail to show profitable results from the use of these preparations. The results sometimes obtained are more often due to the liberal feeding and good care advocated in the accompanying directions than to any value in the "food." Henry & Morrison in Feeds & Feeding say on this point, "Rather than purchase advice with costly condimental foods the wise feeder will secure it in standard agricultural papers and books or from the experiment stations and the United States Department of Agriculture. Farm animals managed with reasonable care have appetites which do not need stimulating. Sick animals or those out of condition should receive specific treatment rather than be given some cure-all."

To cover the infrequent cases where "tonics" or "spices" are needed to sharpen the appetite especially, the following formulae are suggested by the authors quoted above:

No. 1.

Fenugreek...........	2 lbs.
Allspice............	2 lbs.
Gentian.............	4 lbs.
Salt................	5 lbs.
Salt Peter..........	5 lbs.
Epsom Salts........	10 lbs.
Linseed Meal........	100 lbs.

No. 2.

Ground Gentian.......	4 lbs.
Powdered Saltpeter...	1 lb.
Ground Ginger.......	1 lb.
Powdered Copperas...	1 lb.

Formula No. 1, given a tablespoon with each feed, will supply more drugs than most of the much advertised stock feeds or tonics. Formula No. 2 may be given at the rate of one tablespoonful daily mixed with the feed for ten days, then omitted for three days and then given for ten days more. No drugs or tonics should be given healthy animals.

As a general tonic to be used when the appetite is not seriously impaired and when one desires to build up the general condition of the animal, the veterinary department of the College suggests the following as suitable for all kinds of livestock:

Sodium Sulfate (dried)	5 oz.
Sodium Bicarbonate	4½ oz.
Sodium Chloride	2 oz.
Potassium Sulfate	2 drams.

Mix and feed with grain in tablespoonful doses to horses and cattle and teaspoonful doses to pigs and sheep two or three times daily until condition improves. With this an occasional dose of saltpeter in the drinking water—a teaspoonful to a pailful—will work advantageously if fattening is especially desired.

ANALYSES OF FEEDING STUFFS FOR 1917-1918.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTONSEED MEAL.						
	American Cotton Oil Co., New York, N. Y.						
		G.*	.....	36.0	5.5	14.0	....
B 1934	Surety Brand Cottonseed Meal	Detroit F.*	8.7	35.9	7.0	13.8	$53.00
B 2597	Surety Brand Cottonseed Meal	Holland	9.1	39.0	6.4	12.7	60.00
B 2671	Surety Brand Cottonseed Meal	Jamestown	8.2	35.9	7.4	6.8	54.00
B 2678	Surety Brand Cottonseed Meal	Bangor	8.4	36.2	7.4	12.1	60.00
B 2703	Surety Brand Cottonseed Meal	Adrian	8.5	36.5	7.4	12.4	53.50
B 2807	Surety Brand Cottonseed Meal	Dundee	8.0	36.8	7.2	12.2	58.00
B 2809	Surety Brand Cottonseed Meal	Milan	8.5	36.3	6.8	12.2	56.00
B 2817	Surety Brand Cottonseed Meal	Caro	8.8	**34.8**	6.7	13.5	2.75
B 2818	Surety Brand Cottonseed Meal	Pigeon	8.2	36.9	6.7	13.2	52.00
B 2849	Surety Brand Cottonseed Meal	Sandusky	9.0	36.6	6.2	14.0	3.30
B 2882	Surety Brand Cottonseed Meal	Adrian	8.8	35.3	6.3	13.4	....
B 2976	Surety Brand Cottonseed Meal	Clio	9.9	36.0	6.4	13.6	58.00
B 3013	Surety Brand Cottonseed Meal	Alma	8.5	35.5	7.3	13.3	60.00
B 3051	Surety Brand Cottonseed Meal	Grand Rapids	8.5	**32.9**	6.4	14.2	58.00
B 3058	*Surety Brand Cottonseed Meal*	*Grand Rapids*	8.3	36.1	7.5	9.1	54.00
B 3074	Surety Brand Cottonseed Meal	Grand Rapids	8.4	37.6	7.2	11.1	60.00
B 3264	*Surety Brand Cottonseed Meal*	*Schoolcraft*	8.9	37.1	6.7	**15.4**	2.75
B 3310	Surety Brand Cottonseed Meal	Mason	8.3	36.3	6.0	14.5	55.00
B 3320	*Surety Brand Cottonseed Meal*	*Detroit*	8.8	37.9	6.2	13.5	55.00
		Average	8.6	36.3	6.8	12.7	....
	J. E. Bartlett Co. Jackson, Mich.						
		G.*	.....	38.6	5.0	18.0	....
B 2666	Farmer Brand Prime Cottonseed Meal	Jackson F.*	8.8	**36.6**	7.7	9.8	$60.00
B 2900	Farmer Brand Prime Cottonseed Meal	Albion	8.9	40.6	6.8	10.9	....
B 2910	Farmer Brand Prime Cottonseed Meal	Constantine	8.8	40.8	7.0	10.0	54.00
B 3098	Farmer Brand Prime Cottonseed Meal	Allegan	6.8	40.1	6.3	12.0	58.00
		Average	8.3	39.4	7.0	10.7	....
		G.*	.....	36.0	6.0	12.0	....
B 1868	Farmer Brand Straight Cottonseed Meal	Coldwater F.*	8.3	45.6	7.9	7.8	$54.00
B 1869	Farmer Brand Straight Cottonseed Meal	Adrian	7.5	36.9	7.0	**13.6**	53.59
B 2486	Farmer Brand Straight Cottonseed Meal	Coopersville	8.7	36.3	7.0	**14.1**	51.00
B 2632	Farmer Brand Straight Cottonseed Meal	Kalamazoo	8.5	37.5	6.7	12.0	....
B 2822	Farmer Brand Straight Cottonseed Meal	Marlette	8.0	35.8	8.5	12.2	*54.00
B 2904	Farmer Brand Straight Cottonseed Meal	Three Rivers	8.2	35.4	6.6	**13.2**	56.00
B 2930	Farmer Brand Straight Cottonseed Meal	Morrice	8.7	**33.8**	7.4	**13.2**	58.00
B 3018	Farmer Brand Straight Cottonseed Meal	Mt. Pleasant	6.5	36.3	6.5	**14.1**	55.00
B 3206	*Farmer Brand Straight Cottonseed Meal*	*Oxford*	8.8	36.9	7.5	10.5	56.00
B 3207	Farmer Brand Straight Cottonseed Meal	Rochester	8.3	35.9	6.9	12.1	56.00
B 3266	*Farmer Brand Straight Cottonseed Meal*	*Constantine*	8.3	35.8	6.4	**15.1**	56.00
B 3274	Farmer Brand Straight Cottonseed Meal	Hillsdale	8.2	36.6	6.7	**15.2**	58.00
B 3282	*Farmer Brand Straight Cottonseed Meal*	*Kalamazoo*	9.1	36.6	6.6	12.4	....
B 3283	Farmer Brand Straight Cottonseed Meal	Kalamazoo	8.9	35.7	7.0	12.8	2 90
B 3298	*Farmer Brand Straight Cottonseed Meal*	Battle Creek	8.8	**34.9**	8.3	**17.1**	57 00
		Average	8.2	36.1	7.0	13.0	....
	F. W. Brode & Co., Memphis, Tenn.						
B 2823	Jay Brand Cottonseed Meal	Fremont G.*	.....	36.0	5.0	14.0	....
		F.*	8.4	37.3	7.3	10.4	$52 00
B 2963	Jay Brand Cottonseed Meal	Saginaw	9.6	36.2	5.3	11.7	....
B 2999	Jay Brand Cottonseed Meal	Pontiac	9.1	36.8	5.8	11.3	2 90
B 3026	Jay Brand Cottonseed Meal	Reed City	7.9	36.5	6.5	13.8	60 00
B 3027	Jay Brand Cottonseed Meal	Reed City	7.8	36.2	6.3	13.3	60 00
B 3035	Jay Brand Cottonseed Meal	Le Roy	8.5	35.7	6.8	13.8	58 00
B 3120	Jay Brand Cottonseed Meal	Rockford	8.8	37.5	6.9	13.2	60 00
B 3125	Jay Brand Cottonseed Meal	Jamestown	9.1	35.9	6.6	14.1	54 00
		Average	8.5	36.5	6.4	12.7	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	F. W. Brodie & Co., Memphis, Tenn.—Concluded.						
B 2582	Owl Brand Cottonseed Meal	Sparta G.*	......	41.00	6.0	10.0	....
		F.*	8.4	42.5	6.3	10.4	$51 50
B 3097	Owl Brand Cottonseed Meal	Allegan	7.5	41.3	8.0	9.3	60 00
		Average	8.0	41.9	7.2	9.9	....
	Buckeye Cotton Oil Co., Cincinnati, Ohio.						
B 2672	Buckeye Good Cottonseed Meal	Jamestown G.*	......	36.0	5.0	14.0	....
		F.*	8.2	**33.5**	6.3	**15.3**	$54 00
B 2888	Buckeye Good Cottonseed Meal	Ypsilanti	8.6	35.3	6.0	**15.4**	58 00
B 2960	Buckeye Good Cottonseed Meal	Lansing	8.6	**34.4**	7.0	13.7	2 85
B 2973	Buckeye Good Cottonseed Meal	Birch Run	8.2	39.1	6.9	10.2	2 85
B 3030	Buckeye Good Cottonseed Meal	Big Rapids	8.1	35.5	5.2	**15.1**	60 00
B 3214	Buckeye Good Cottonseed Meal	Chesaning	8.8	35.2	5.7	**15.9**	55 00
B 3299	Buckeye Good Cottonseed Meal	Battle Creek	8.6	**33.9**	7.7	14.6	60 00
B 3308	Buckeye Good Cottonseed Meal	Lansing	8.2	36.0	5.4	**15.5**	56 00
		Average	8.4	35.4	6.3	14.5	....
	S. P. Davis, Little Rock, Ark.						
B 3017	Good Luck Brand Cottonseed Meal	Mt. Pleasant G.*	......	41.0	6.0	9.0	....
		F.*	7.6	**38.0**	6.2	**13.7**	$58 00
B 3021	Good Luck Brand Cottonseed Meal	Shepherd	8.0	**37.6**	5.8	**14.3**	60 00
		Average	7.8	**37.8**	6.0	**14.0**	....
B 2687	Veribest Cottonseed Meal	Watervliet G.*	......	38.5	6.0	10.0	....
		F.*	8.7	39.0	6.8	**11.3**	$60 00
B 2858	Veribest Cottonseed Meal	Elkton	8.1	**35.2**	6.0	**14.2**	....
B 3329	Veribest Cottonseed Meal	Clinton	8.3	**37.0**	6.2	**11.5**	50 00
		Average	8.4	**37.1**	6.3	**12.3**	....
	East St. Louis Cotton Oil Co., National Stock Yards, Ill.						
B 2795	East St. Louis Cottonseed Meal	Ann Arbor G.*	......	38.5	6.0	12.0	....
		F.*	8.4	40.0	6.8	10.5	$58 50
B 1870	St. Clair Brand Cottonseed Meal	Adrian G.*	......	36.0	5.0	16.0	....
		F.*	7.6	35.5	5.7	14.4	53 50
B 1982	St. Clair Brand Cottonseed Meal	Clinton	8.8	35.1	6.0	13.0	55 00
B 1986	St. Clair Brand Cottonseed Meal	Blissfield	7.7	38.7	6.6	11.2	53 00
B 2571	St. Clair Brand Cottonseed Meal	N. Muskegon	8.0	36.1	6.4	13.3	55 00
B 2601	St. Clair Brand Cottonseed Meal	Holland	8.0	38.0	6.2	12.3	61 00
B 2618	St. Clair Brand Cottonseed Meal	Plainwell	9.4	38.9	6.7	12.5	56.00
B 2745	St. Clair Brand Cottonseed Meal	Leslie	8.5	36.7	6.4	12.1	3 00
B 2806	St. Clair Brand Cottonseed Meal	Manchester	7.7	39.6	6.7	11.6	....
B 2811	St. Clair Brand Cottonseed Meal	Grass Lake	8.8	36.8	6.7	11.6	55 00
B 3103	St. Clair Brand Cottonseed Meal	Coopersville	8.7	36.1	5.8	13.6	55 00
B 3105	St. Clair Brand Cottonseed Meal	Grandville	9.5	**34.6**	5.4	14.2	....
B 3107	St. Clair Brand Cottonseed Meal	Vriesland	8.1	37.6	6.9	11.4	60 00
B 3223	St. Clair Brand Cottonseed Meal	Richmond	8.8	36.5	6.5	12.3	3 00
B 3251	St. Clair Brand Cottonseed Meal	Adrian	9.2	36.1	5.6	13.8	2 83
B 3281	St. Clair Brand Cottonseed Meal	Kalamazoo	8.9	36.0	5.8	13.7	55 00
B 3294	St. Clair Brand Cottonseed Meal	Plainwell	8.8	35.9	6.0	14.2	3 00
B 3301	St. Clair Brand Cottonseed Meal	Jackson	8.8	36.4	5.5	12.7	58 00
		Average	8.5	36.7	6.2	12.8	....
	Feeders Supply Co., Kansas City, Mo.						
B 2636	Equity Brand Cottonseed Meal	Kalamazoo G.*	......	36.0	5.0	14.0	....
		F.*	7.6	36.8	7.6	11.8	$58 00
	Hayes Grain & Commission Co., Little Rock, Ark.						
B 2873	Arkansaw Brand Cottonseed Meal	Jackson G.*	......	36.0	5.0	15.0	....
		F.*	6.7	35.1	5.8	16.0	....
B 2991	Arkansaw Brand Cottonseed Meal	Holly	8.1	37.4	6.0	15.1	....
B 3302	Arkansaw Brand Cottonseed Meal	Jackson	8.0	36.7	6.2	12.6	58 00
		Average	7.6	36.4	6.0	14.6	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Humphreys-Godwin Co., Memphis, Tenn.							
B 2508	Danish Cottonseed Meal	Grand Rapids	G.*	......	36.0	5.0	15.0	....
			F.*	8.0	36.4	6.9	14.5	$54 00
B 2535	Danish Cottonseed Meal	Grandville		7.5	35.8	5.7	15.7	56 00
B 2557	Danish Cottonseed Meal	Muskegon		7.9	34.7	6.3	13.6	55 00
B 2574	Danish Cottonseed Meal	Sparta		8.2	37.5	7.0	12.7	58 00
B 2583	Danish Cottonseed Meal	Vriesland		7.9	36.2	6.3	13.9	57 00
B 2591	Danish Cottonseed Meal	Forrest Grove		7.9	37.0	6.6	12.9	55 00
B 2674	Danish Cottonseed Meal	Fennville		8.7	34.6	5.8	15.0	57 00
B 3054	Danish Cottonseed Meal	Grand Rapids		8.6	38.0	6.4	12.2	60 00
B 3100	Danish Cottonseed Meal	Conklin		8.0	37.6	5.9	13.7	55 00
B 3117	Danish Cottonseed Meal	Petoskey		7.6	36.1	6.1	14.6	62 00
		Average		8.0	36.7	6.3	13.9	....
B 3136	Dixie Brand Cottonseed Meal	Fremont	G.*	......	41.0	5.5	10.0	....
			F.*	8.4	42.7	7.6	9.2	$57 00
	Interstate Feed Association, Detroit, Mich.							
B 2953	Superior Brand Cottonseed Meal	Bay City	G.*	......	38.6	6.0	12.0	....
			F.*	8.4	39.4	7.3	10.2	3 25
B 3216	Superior Brand Cottonseed Meal	Eaton Rapids		9.4	38.8	7.5	11.0	3 00
		Average		8.9	39.1	7.4	10.6	....
	National Feed Co. St., Louis, Mo.							
B 2896	Cottonseed Meal	Devereaux	G.*	......	38.5	6.5	14.0	....
			F.*	9.2	40.2	7.5	9.7	....
	W. C. Northern, Little Rock, Ark.							
B 3057	Butterfly Meal	Grand Rapids	G.*	......	38.6	6.0	12.0	....
			F.*	8.5	38.7	6.1	10.6	$60 00
B 3045	Standard Brand Cottonseed Meal	Cedar Springs	G.*	......	36.0	5.0	12.0	....
			F.*	8.2	37.0	5.8	14.2	60 00
B 3048	Standard Brand Cottonseed Meal	Comstock Park		9.3	35.0	5.7	15.5	57 00
		Average		8.8	36.0	5.8	14.9	....
	Wagner White Co., Inc., Jackson, Mich.							
B 2625	Wawco Brand Cottonseed Meal	Marshall	G.*	......	36.0	5.0	22.0	....
			F.*	7.4	37.4	6.4	13.1	....
B 2731	Wawco Brand Cottonseed Meal	Mason		7.6	31.7	5.9	16.3	$3 75
B 2796	Wawco Brand Cottonseed Meal	Mt. Clemens		7.6	36.9	7.6	11.6	2 70
		Average		7.5	35.3	6.6	13.7	....
	E. L. Wellman, Grand Rapids, Mich.							
B 2675	Feeders Favorite Cottonseed Meal	Fennville	G.*	......	38.6	6.0	12.0	....
			F.*	8.3	41.4	7.4	10.5	$59 00
B 3032	Feeders Favorite Cottonseed Meal	Cadillac		8.1	36.5	6.8	12.7	60 00
B 3151	Feeders Favorite Cottonseed Meal	Coopersville		8.7	37.2	8.1	13.5	57 00
		Average		8.4	38.4	7.4	12.2	....
	COTTONSEED FEED.							
	American Cotton Oil Co., New York, N. Y.							
B 2633	Columbia Cottonseed Feed	Kalamazoo	G.*	......	26.5	3.0	25.0	....
			F.*	8.6	23.8	4.3	22.9	$50 00
B 3029	Columbia Cottonseed Feed	Reed City		9.8	19.7	3.4	24.0	....
		Average		9.2	21.8	3.9	23.5	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	S. P. Davis, Little Rock, Ark.						
B 2692	Beauty Brand Cottonseed Feed	Benton Harbor G.*	......	36.0	6.0	14.0	....
		F.*	9.2	36.2	6.4	12.2	$60 00
B 3010	Beauty Brand Cottonseed Feed	Lake Odessa	7.8	35.6	5.9	13.3	....
B 3244	Beauty Brand Cottonseed Feed	Flint	8.5	35.8	6.0	13.6	....
		Average	8.5	35.9	6.1	13.0	....
	Humphreys-Godwin Co., Memphis, Tenn.						
B 3053	No. 77 Cottonseed Feed	Grand Rapids G.*	......	20.0	4.0	28.0	....
		F.*	8.7	20.2	3.2	26.4	$50 00
B 3099	No. 77 Cottonseed Feed	Conklin	8.0	21.1	3.2	25.7	40 00
		Average	8.4	20.7	3.2	26.1	....
	Tennessee Fibre Co., Memphis, Tenn.						
B 3260	Creamo Brand Cottonseed Feed	Jackson G.*	......	20.0	4.0	25.0	....
		F.*	10.4	19.0	3.7	22.2	$2 25
	LINSEED MEAL.						
	American Linseed Co., Buffalo, N. Y.						
B 2509	O. P. Linseed Oil Meal	Grand Rapids G.*	......	34.0	5.0	8.0	....
		F.*	10.0	34.3	5.4	8.2	60 00
B 2565	O. P. Linseed Oil Meal	Muskegon	9.2	38.0	6.0	7.4	66 00
B 2659	O. P. Linseed Oil Meal	Battle Creek	9.0	36.6	6.1	7.8	63 00
B 2715	O. P. Linseed Oil Meal	Hudson	9.7	34.7	5.4	8.5	3 20
B 2787	O. P. Linseed Oil Meal	Ann Arbor	9.1	36.5	6.1	7.3	3 15
B 2833	O. P. Linseed Oil Meal	Imlay City	9.0	38.4	6.5	7.2	3 00
B 2929	O. P. Linseed Oil Meal	Morrice	8.4	36.8	6.2	7.7	3.25
B 2962	O. P. Linseed Oil Meal	Saginaw	10.5	33.9	5.2	8.1	....
		Average	9.4	36.2	5.9	7.8	....
	American Milling Co., Peoria, Ill.						
B 1991	Amco O. P. Linseed Meal	Morenci G.*	......	30.0	5.0	10.0	....
		F.*	10.2	26.4	6.4	10.0	$58 00
B 2515	Amco O. P. Linseed Meal	Grand Rapids	10.3	28.4	6.0	10.0	64 00
B 2711	Amco O. P. Linseed Meal	Adrian	10.0	27.7	6.2	10.0	59 00
B 2936	Amco O. P. Linseed Meal	Saginaw	10.1	30.9	7.4	9.4	3 25
B 2947	Amco O. P. Linseed Meal	Bay City	9.4	28.6	6.7	9.8	3 00
B 2961	Amco O. P. Linseed Meal	Saginaw	10.9	31.9	7.4	8.9	....
B 3005	Amco O. P. Linseed Meal	Mulliken	9.3	32.1	6.8	9.3	70 00
B 3022	Amco O. P. Linseed Meal	Clare	10.5	32.8	6.3	3.7	65 00
B 3047	Amco O. P. Linseed Meal	Cedar Springs	9.5	31.9	5.2	8.8	65 00
B 3081	Amco O. P. Linseed Meal	Grand Rapids	10.7	30.8	6.4	9.0	64 00
B 3137	Amco O. P. Linseed Meal	Fremont	10.0	31.1	6.4	10.5	63 00
		Average	10.1	30.2	6.5	9.0	....
	Archer Daniels Linseed Co., Minneapolis, Minn.						
B 2903	Old Process Ground Oil Cake Meal	Albion G.*	......	33.0	6.0	10.0	....
		F.*	9.1	36.1	6.7	8.4	$3 20
	Chicago Heights Oil Manufacturing Co., Chicago Illinois.						
B 1908	O. P. Laxo Cake Meal	Detroit G.*	......	25.0	6.0	12.0	....
		F.*	10.2	28.2	7.7	9.5	3 00
B 3233	O. P. Laxo Cake Meal	Royal Oak	9.3	31.1	7.5	9.4	3 15
		Average	9.8	29.7	7.6	9.5	....
B 2685	O. P. Oil Meal	Hartford G.*	......	32.0	6.0	10.0	....
		F.*	12.9	37.6	7.4	6.6	$65 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Hirst & Begley Linseed Co., Chicago, Illinois.							
B 2484	O. P. Linseed Cake Meal	Grand Rapids	G.*	......	34.0	6.0	9.0	......
			F.*	9.8	**30.8**	6.5	8.9	$60 00
B 2526	O. P. Linseed Cake Meal	Zeeland		9.4	36.3	6.9	8.0	63 00
B 2542	O. P. Linseed Cake Meal	Holland		9.2	36.3	5.6	8.6	60 00
B 2584	O. P. Linseed Cake Meal	Vriesland		8.4	38.1	6.3	7.9	62 00
B 2593	O. P. Linseed Cake Meal	Forrest Grove		8.3	36.3	6.1	8.4	60 00
B 2670	O. P. Linseed Cake Meal	Jamestown		10.0	38.1	5.9	7.4	60 00
B 2673	O. P. Linseed Cake Meal	Jamestown		8.5	36.1	6.7	7.9	60 00
B 2677	O. P. Linseed Cake Meal	Fennville		8.6	36.5	6.8	7.6	65 00
B 2730	O. P. Linseed Cake Meal	Mason		9.4	34.5	6.1	7.8	3 50
B 3084	O. P. Linseed Cake Meal	Grand Rapids		9.0	34.8	6.5	**10.6**	60 00
		Average		9.1	35.8	6.3	8.3	......
	Metzger Seed & Oil Co., Toledo, Ohio.							
B 1924	O. P. Oil Meal	Detroit	G.*	......	30.0	5.0	10.0	......
			F.*	10.0	34.8	7.1	7.7	$3 00
B 1947	O. P. Oil Meal	Detroit		8.8	35.1	5.1	7.7	57 00
B 1985	O. P. Oil Meal	Blissfield		9.3	36.7	7.4	7.7	60 00
B 3011	O. P. Oil Meal	Lake Odessa		9.3	38.4	6.3	7.6	......
		Average		9.4	36.3	6.5	7.7	......
	Midland Linseed Products Co., Minneapolis, Minn.							
B 2630	O. P. Ground Linseed Cake	Kalamazoo	G.*	......	32.0	5.0	9.0	......
			F.*	10.2	34.8	6.3	8.1	$66 00
B 2693	O. P. Ground Linseed Cake	Benton Harbor		9.0	38.2	6.8	7.6	70 00
		Average		9.6	36.5	6.6	7.9	......
	Milwaukee Linseed Oil Works, Milwaukee, Wis.							
B 2598	O. P. Ground Linseed Cake	Holland	G.*	......	32.0	5.0	10.0	......
			F.*	10.1	33.9	7.4	7.6	$60 00
	Sherwin-Williams Co., Cleveland, Ohio.							
B 3247	S. W. C. Linseed Oil Meal	Adrian	G.*	......	33.0	6.0	8.0	......
			F.*	9.3	37.1	6.6	9.0	$3 05
	Spencer-Kellogg Co., Inc., Buffalo, N. Y.							
B 2612	Pure O. P. Oil Meal	Moline	G.*	......	33.0	5.0	10.0	......
			F.*	9.4	37.2	5.8	7.6	$63 00
B 2741	Pure O. P. Oil Meal	Leslie		10.8	32.8	5.8	8.5	3 50
B 2868	Pure O. P. Oil Meal	Jackson		9.3	37.6	6.5	7.5	3 10
B 3149	Pure O. P. Oil Meal	Berlin		10.5	37.3	6.4	7.3	65 00
		Average		10.0	36.2	6.1	7.7	......
	Toledo Seed & Oil Co., Toledo, Ohio.							
B 1883	Major Brand O. P. Oil Meal	Detroit	G.*	......	30.0	5.0	10.0	......
			F.*	9.4	33.1	6.5	9.1	$2 95
B 1955	Major Brand O. P. Oil Meal	Detroit		8.5	33.3	6.4	8.8	3 00
B 1958	Major Brand O. P. Oil Meal	Detroit		8.9	33.5	6.3	8.2	2 90
B 2619	Major Brand O. P. Oil Meal	Plainwell		10.1	34.8	5.9	8.2	65 00
B 2681	Major Brand O. P. Oil Meal	Bangor		10.8	33.6	6.2	7.9	70 00
B 2700	Major Brand O. P. Oil Meal	Greenville		10.6	33.5	6.0	8.3	60 00
B 2775	Major Brand O. P. Oil Meal	Lansing		8.8	35.4	6.2	7.5	3 50
B 2945	Major Brand O. P. Oil Meal	Gladwin		10.9	37.0	5.9	7.4	3 50
		Average		9.8	34.3	6.2	8.2	......

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	DISTILLERS' DRIED GRAINS.						
	Chiefly from Corn.						
	Continental Cereal Co., Peoria, Ill.						
B 2891	Continental Gluten Feed	Monroe G.*	.....	29.0	10.0	10.0	.....
		F.*	7.2	34.3	10.3	9.9	.....
B 2894	Continental Gluten Feed	Ypsilanti	6.1	36.9	15.8	8.9	.....
B 3245	Continental Gluten Feed	Flint	7.6	32.0	10.7	9.4	.....
		Average	7.0	34.4	12.3	9.4	.....
	The Dewey Bros. Co., Blanchester, Ohio.						
B 3303	Eagle 5 D Grains	Leslie G.*	.....	30.0	10.0	13.0	.....
		F.*	29.3	10.1	10.1	17.5	$3 25
	YEAST AND VINEGAR DRIED GRAINS.						
	J. E. Bartlett Co., Jackson, Mich						
B 2726	Bartlett's Malt By-Product	North Adams G.*	.....	18.0	5.0	14.0	.....
		F.*	6.8	20.8	7.6	15.2	.....
B 2863	Bartlett's Malt By-Product	Jackson	7.1	21.1	5.2	11.0	2 25
		Average	7.0	21.1	6.4	13.1	.....
	The Fleischmann Co., Chicago, Ill.						
B 2546	Fleischmann's Dried Grains	Nunica G.*	.....	19.0	7.0	19.0	.....
		F.*	8.1	17.3	6.1	18.8	$52 00
B 2867	Fleischmann's Dried Grains	Jackson	6.7	18.2	6.4	18.0	2 50
B 3085	Fleischmann's Dried Grains	Grand Rapids	8.0	17.9	5.0	18.0	53 00
B 3142	Fleischmann's Dried Grains	Grand Rapids	7.7	18.4	6.1	18.4	.....
		Average	7.6	18.0	5.9	18.3	.....
B 2746	Fleischmann's Dried Malt Grains	Leslie G.*	.....	22.0	7.0	17.0	.....
		F.*	5.0	23.8	9.4	15.1	$2 50
B 2869	Fleischmann's Dried Malt Grains	Jackson	5.4	22.4	8.8	16.4	2 50
B 3102	Fleischmann's Dried Malt Grains	Coopersville	6.1	24.6	9.5	15.5	48 00
		Average	5.5	23.6	9.2	15.7	.....
	Kellogg Toasted Corn Flake Co., Battle Creek, Mich.						
B 2585	Dried Brewers Grains	Vriesland G.*	.....	25.1	5.0	12.7	.....
		F.*	8.4	31.2	4.8	11.3	$50 00
B 2654	Dried Brewers Grains	Battle Creek	5.6	29.4	5.8	12.1	45 00
B 2716	Dried Brewers Grains	Hudson	6.7	25.2	5.4	10.7	2 50
B 2802	Dried Brewers Grains	Monroe	8.8	31.9	5.5	11.9	.....
		Average	7.6	31.9	5.4	11.5	.....
	DRIED BREWERS' GRAINS.						
	K. & E. Neumond, St. Louis, Mo.						
B 1941	Goldnes Kalb Dried Brewers Grains	Detroit G.*	.....	24.0	6.0	13.0	.....
		F.*	7.0	24.3	5.1	15.2	.....
	CORN GLUTEN FEED.						
	American Maize Products Co., New York, N. Y.						
B 2789	Cream of Corn Gluten Feed	Ann Arbor G.*	.....	23.0	1.5	8.5	.....
		F.*	10.0	25.0	1.6	6.2	$2 65
B 2793	Cream of Corn Gluten Feed	Ann Arbor	9.7	24.5	1.4	6.0	53 00
		Average	9.9	24.8	1.5	6.1	.....

***Abbreviations for Guaranteed and Found.**

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Clinton Sugar Refining Co., Clinton, Iowa.							
B 2712	Clinton Corn Gluten Feed	Adrian	G.*	......	23.0	3.0	8.0	....
			F.*	8.5	26.0	2.4	7.0	$58 00
	Corn Products Refining Co., New York, N. Y.							
B 1920	Buffalo Corn Gluten Feed	Detroit	G.*	......	23.0	1.0	8.5	....
			F.*	9.7	25.0	3.2	7.7	2 75
B 1945	Buffalo Corn Gluten Feed	Detroit		8.4	28.9	1.5	8.1	54 00
B 1994	Buffalo Corn Gluten Feed	Morenci		9.5	28.0	1.4	7.2	57 00
B 2476	Buffalo Corn Gluten Feed	Grand Rapids		9.5	28.3	1.4	7.4	56 00
B 2765	Buffalo Corn Gluten Feed	Lansing		12.6	25.7	1.3	7.4	3 25
B 2777	Buffalo Corn Gluten Feed	Lansing		9.8	29.2	1.5	6.7	3 00
		Average		9.8	27.5	1.7	7.4	....
	Douglas Company, Cedar Rapids, Ia.							
B 2567	Douglas Corn Gluten Feed	Muskegon	G.*	......	23.0	1.0	8.0	....
			F.*	8.8	26.7	1.6	8.4	$52 00
B 2701	Douglas Corn Gluten Feed	Adrian		8.9	26.3	1.4	6.6	58 00
		Average		8.9	26.5	1.5	7.5	....
	J. C. Hubinger Bros. Co., Keokuk, Ia.							
B 2892	KKK Corn Gluten Feed	Ypsilanti	G.*	......	23.0	2.4	7.5	....
			F.*	9.0	22.1	3.6	6.6	$60 00
	Huron Milling Co., Harbor Beach, Mich.							
B 2830	Jenks Corn Gluten Feed	Bad Axe	G.*	......	22.0	3.0	8.0	....
			F.*	7.9	25.2	4.7	7.6	3 00
B 2838	Jenks Corn Gluten Feed	Pt. Huron		9.2	25.6	4.2	7.4	57 00
B 2857	Jenks Corn Gluten Feed	Harbor Beach		8.2	25.4	3.0	7.7	2 95
		Average		8.4	25.4	4.0	7.6	....
	CORN GLUTEN MEAL.							
	Corn Products Refining Co., New York, N. Y.							
B 2773	Diamond Corn Gluten Meal	Lansing	G.*	......	40.0	1.0	4.0	....
			F.*	6.6	44.1	0.7	1.2	....
	HOMINY FEEDS.							
	Beck Cereal Co., Detroit, Mich.							
B 3237	Royal Hominy Feed Meal	Detroit	G.*	......	10.0	6.0	6.0	....
			F.*	11.5	10.4	5.8	4.3	....
B 3239	Royal Hominy Feed Meal	Detroit		13.1	10.6	6.9	5.0	....
		Average		12.3	10.5	6.4	4.7	....
	Evans Milling Co., Indianapolis, Indiana.							
B 3230	Hominy Feed	Birmingham	G.*	......	10.0	7.5	7.0	....
			F.*	10.6	10.0	6.8	4.7	$3 10
	Chas. A. Krause Milling Co., Milwaukee, Wisconsin.							
B 1951	Badger Hominy Feed	Detroit	G.*	......	10.0	6.0	5.0	....
			F.*	5.2	11.3	6.6	4.5	....
B 1978	Badger Hominy Feed	Clinton		10.8	11.1	7.4	4.8	65 00
B 2475	Badger Hominy Feed	Grand Rapids		9.6	11.4	7.5	5.6	62 00
B 2559	Badger Hominy Feed	Muskegon		9.2	10.2	8.3	4.9	65 00
		Average		8.7	11.0	7.7	5.0	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	CORN OIL CAKE MEAL.							
	American Hominy Co., Indianapolis, Indiana.							
B 3257	Homcoline Feed	Jackson	G.*	......	17.0	5.0	7.0	....
			F.*	6.4	17.0	7.5	4.7	....
	Chicago Heights Oil Mfg. Co., Chicago, Illinois.							
B 2755	Heights Corn Oil Cake Meal	St. Johns	G.*	......	*18.0*	*8.0*	*10.0*	....
			F.*	10.6	23.7	7.0	8.4	$3 00
B 3156	Heights Corn Oil Cake Meal	Holland		13.2	16.9	7.8	7.0	....
		Average		11.9	20.3	7.4	7.7	....
	Clinton Sugar Refining Co., Clinton, Iowa.							
B 2880	*Clinton Corn Oil Cake Meal*	*Morenci*	G.*	......	*20.0*	7.7	*12.0*	....
			F.*	8.9	19.8	10.4	8.2	$66 00
	Corn Products Refining Co., New York, N. Y.							
B 2905	Argo Corn Oil Cake Meal	Constantine	G.*	......	18.0	7.0	13.0	....
			F.*	9.3	19.5	11.4	10.0	3 50
B 2907	Argo Corn Oil Cake Meal	Constantine		10.7	19.1	8.9	9.1	3 25
		Average		10.0	19.3	10.2	9.6	....
B 2831	*Diamond Hog Meal*	*Adrian*	G.*	......	*18.0*	7.0	*13.0*	....
			F.*	9.7	20.6	9.2	9.4	....
B 3138	Diamond Hog Meal	Fremont		8.9	16.7	11.7	10.9	$65 00
		Average		9.3	18.7	10.5	10.2	....
	CORN FEED MEAL.							
	Commercial Milling Co., Detroit, Mich.							
B 1902	Henkel's Coarse Feed Corn Meal	Detroit	G.*	......	8.5	......	2.0	....
			F.*	*10.8*	*11.8*	6.1	2.9	....
B 1919	Henkel's Coarse Feed Corn Meal	Detroit		11.8	10.4	5.9	2.7	....
		Average		*11.3*	*11.1*	*6.0*	*2.8*	....
	Dahnke Walker Milling Co., Union City, Tenn.							
B 2641	Danco Feed Offal from White Corn	Allegan	G.*	......	10.0	7.0	6.0	....
			F.*	10.2	9.6	6.6	7.0	$70 00
B 2907	Danco Feed Offal from White Corn	Allegan		10.8	10.4	6.3	7.2	3 75
		Average		10.5	10.0	6.5	7.1	....
	Darrah Milling Co., Big Rapids, Mich.							
B 3040	Unbolted Corn Meal	Big Rapids	G.*	......	10.2	4.6	3.2	....
			F.*	13.8	9.1	4.4	2.5	$80 00
	King Milling Co., Lowell, Mich.							
B 2469	King Corn Meal	Coopersville	G.*	......	9.5	7.3	3.6	....
			F.*	12.4	9.7	5.3	4.2	78 00
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
B 2751	*Badger Maizo Rodding Flour*	St. Johns	G.*	......	*10.5*	2.0	*2.0*	....
			F.*	11.2	11.9	8.8	2.4	3 25

***Abbreviations for Guaranteed and Found.**

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Larrowe Milling Co., Detroit, Mich.							
B 3232	Corn Feed Meal	Birmingham	G.*	......	9.0	5.0	6.0	....
			F.*	10.7	10.0	6.2	4.8	$3 10
B 3277	Corn Feed Meal	Tecumseh		14.0	8.8	5.0	4.3	70 00
		Average		*12.4*	*9.4*	*5.6*	*4.6*	....
	David Stott Flour Mill Co., Detroit, Mich.							
B 3315	Yellow Corn Feed Meal	Detroit	G.*	......	10.0	6.0	5.0	....
			F.*	12.5	9.6	5.2	4.8	$3 90
	Valley City Milling Co., Grand Rapids, Mich.							
B 2504	Rowena Coarse Meal with ground screenings not exceeding mill run.	Grand Rapids	G.*	......	9.1	4.5	3.0	....
			F.*	12.1	10.1	4.7	3.1	80 00
B 2520	Rowena Coarse Meal with ground screenings not exceeding mill run.	Grand Rapids		11.6	9.6	5.8	3.5	82 00
B 2592	Rowena Coarse Meal with ground screenings not exceeding mill run.	Forrest Grove		11.5	9.8	5.5	2.8	82 00
B 3078	Rowena Coarse Meal with ground screenings not exceeding mill run.	Grand Rapids		12.9	9.6	5.5	3.1	74 00
		Average		12.0	9.8	5.4	3.1	....
	Watson Higgins Milling Co., Grand Rapids, Mich.							
B 3141	Corn Feed Offal	Grand Rapids	G.*	......	10.5	8.0	7.0	....
			F.*	11.0	10.6	8.4	6.3	....
B 3147	Corn Feed Offal	Hudsonville		12.3	10.7	4.5	4.8	$60 00
		Average		11.7	10.7	6.5	5.8	....
	ANIMAL BY-PRODUCTS.							
	Darling & Company, Chicago, Illinois.							
B 2725	Darling's 60% Digester Tankage	North Adams	G.*	......	60.0	0.5	3.0	....
			F.*	9.9	61.3	0.7	3.0	$4 75
B 3297	Darling's 60% Digester Tankage	Galesburg		9.7	70.0	2.0	4.2	5 50
		Average		9.8	65.7	1.4	3.6	....
B 3296	Darling's 40% Feeding Tankage	Galesburg	G.*	......	40.0	0.5	5.0	....
			F.*	10.5	46.6	1.1	6.0	$4 50
B 2866	Granulated Bone for Poultry	Jackson	G.*	......	20.0	0.5	3.0	....
			F.*	7.1	26.1	1.4	1.3	4 50
B 3201	Granulated Bone for Poultry	Pontiac		6.7	24.4	4.7	1.6	4 25
		Average		6.9	25.3	3.2	1.5	....
B 1878	Darling's 50% Meat Scraps	Detroit	G.*	......	50.0	0.5	3.0	....
			F.*	8.3	54.4	7.0	3.7	$4 35
B 1927	Darling's 50% Meat Scraps	Detroit		8.7	54.9	6.9	4.3	4 00
B 2512	Darling's 50% Meat Scraps	Grand Rapids		8.4	53.4	6.6	3.3	5 00
B 2605	Darling's 50% Meat Scraps	Holland		9.1	57.4	6.3	3.7	95 00
B 2680	Darling's 50% Meat Scraps	Bangor		9.1	52.6	7.4	3.3	100 00
B 3067	Darling's 50% Meat Scraps	Zeeland		7.9	54.2	8.0	3.4	5 75
B 3328	Darling's 50% Meat Scraps	Morenci		11.3	56.1	1.4	3.3	5 50
		Average		9.0	54.7	6.2	3.6	....
B 2747	Darling's Standard Meat Scraps	St. Johns	G.*	......	45.0	0.5	3.0	....
			F.*	9.8	54.1	5.3	4.6	$5 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number	Manufacturer and Trade Name.	Sampled at	Moisture	Crude protein.	Crude fat.	Crude fiber	Price per ton or cwt.
	Hartman Tankage Works, Grand Rapids, Mich.						
B 3096	Hartman Tankage	Grand Rapids G.*	......	48.0	2.5	1.0	....
		F.*	8.8	48.8	10.3	2.1	$90 00
	Millenbach Bros., Detroit, Mich.						
B 1928	Millenbach's Mixed Beef Scraps	Detroit G.*	......	45.0	10.0	......	....
		F.*	8.8	50.0	10.2	2.3	4 00
	Morris & Company, Chicago, Ill.						
B 2754	Big Brand Digester Tankage	St. Johns G.*	......	60.0	7.0	5.0	....
		F.*	7.4	59.1	8.2	3.3	5 00
	Swift & Company, Chicago, Ill.						
B 1984	Digester Tankage	Blissfield G.*	......	60.0	6.0	3.0	....
		F.*	7.8	61.2	0.5	1.7	95 00
B 2710	Digester Tankage	Adrian	8.5	65.0	4.6	1.5	5 00
B 3203	*Digester Tankage*	*Pontiac*	7.3	62.5	6.8	2.1	5 00
		Average	7.9	62.9	4.0	1.8	....
B 2499	Meat Scraps	Grand Rapids G.*	......	50.0	8.0	3.0	....
		F.*	7.0	52.8	9.5	3.6	$98 00
B 2709	Meat Scraps	Adrian	6.0	53.7	9.6	2.6	5 00
B 2763	Meat Scraps	Lansing	6.6	50.6	9.6	2.6	5 00
B 3202	Meat Scraps	Pontiac	7.3	54.9	10.0	2.5	5 00
		Average	6.7	53.0	9.7	2.8	....
B 1927	Poultry Bone Meal	Detroit G.*	......	25.0	2.0	3.0	....
		F.*	6.9	17.6	5.0	1.3	2 25
B 3205	Poultry Bone Meal	Pontiac	8.4	25.2	1.6	0.7	4 25
		Average	7.7	21.4	3.2	1.0	....
B 2713	Soluble Blood Flour	Adrian G.*	......	80.0	......	3.0	....
		F.*	9.6	83.5	14.4	1.0	$7 00
	S. I. Treat & Son, Coldwater, Mich.						
B 3218	Old Hoss Brand Tankage	Coldwater G.*	......	44.9	7.7	1.4	....
		F.*	7.7	52.8	12.7	4.6	70 00
	ALFALFA MEAL.						
	American Milling Co., Peoria, Ill.						
B 1922	Alfalfa Meal	Detroit G.*	......	12.0	......	35.0	....
		F.*	8.9	13.4	1.3	29.1	....
B 3231	Alfalfa Meal	Birmingham	8.6	15.9	2.2	28.6	2.00
		Average	8.8	14.7	1.8	28.9	....
	Denver Alfalfa Milling & Products Co., Hartman, Colorado.						
B 3325	Alfalfa Meal	Detroit G.*	......	12.0	1.5	35.0	....
		F.*	9.2	15.0	1.2	30.5	$2 40
	Henderson Milling Co., Grand Rapids, Mich.						
B 2479	Alfalta Meal	Grand Rapids G.*	......	16.3	1.5	29.2	....
		F.*	8.3	14.6	1.6	29.2	39 00
B 2493	Altalfa Meal	Grand Rapids	8.9	16.3	1.5	29.2	45 00
B 3079	Alfalta Meal	Grand Rapids	9.7	16.8	1.9	21.3	45 00
		Average	9.0	15.9	1.7	26.6	....

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein	Crude fat.	Crude fiber.	Price per ton or cwt.
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
B 2479	Alfalfa Meal	Grand Rapids	G.*	......	14.0	1.0	30.0	....
			*F.**	*8.3*	*14.6*	*1.6*	*29.2*	....
B 2676	Alfalfa Meal	Fennville		9.4	15.8	1.6	26.8	$44 00
B 2772	Alfalfa Meal	Lansing		8.0	15.6	1.2	28.1	2 50
B 3052	Alfalfa Meal	Grand Rapids		9.1	16.3	1.4	28.0	....
		Average.		*8.7*	*15.6*	*1.5*	28.0	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	CALF MEAL.							
	American Milling Co., Peoria, Ill.							
B 1933	Sucrene Calf Meal	Detroit G.*	......	20.0	4.0	3.0	....	Linseed meal, bone meal, blood flour, wheat middlings, corn meal, dried skim milk, malt flour, soluble starch.
		F.*	10.9	17.9	3.1	3.7	$4 50	
	Blatchford's Calf Meal Factory, Waukegan, Ill.							
B 1923	Blatchford's Calf Meal	Detroit G.*	......	24.0	5.0	6.8	....	Cottonseed meal, linseed meal, blood meal, wheat flour, locust bean meal, unpressed *flaxseed, barley and malt sprouts meal*, rice polish, ground beans and peas, cocoanut meal, cocoa shell meal, dried milk, foenurgreek, anise, salt.
		F.*	10.7	24.7	6.5	7.4	4 50	
B 1997	Blatchford's Calf Meal	Adrian	10.3	24.8	6.4	6.9	5 00	Same as B 1923.
B 2496	Blatchford's Calf Meal	Grand Rapids	10.1	21.6	7.8	7.0	84 00	Same as B 1923.
B 2771	Blatchford's Calf Meal	Lansing	11.2	25.8	7.1	7.5	4 75	Same as B 1923.
		Average	10.6	24.2	7.0	7.2	....	
	Hales & Edwards Co., Chicago, Ill.							
B 2788	Red Horn Calf Meal	Lansing G.*	......	24.0	5.0	7.0	....	Linseed meal, oat flour red dog flour, alfalfa, corn flour, barley flour, dextrose, *calcium carbonate* salt.
		F.*	10.8	19.6	4.6	4.5	$5 25	
	International Sugar Feed, Co., Minneapolis, Minn.							
B 2031	Grofast Calf Meal	Morrice G.*	......	25.0	5.0	10.0	....	Linseed meal, red dog flour, grain screenings, locust bean meal, foenurgreek.
		F.*	9.1	27.1	6.3	8.6	5 00	
	J. C. Martin Co., Mineral Point, Wis.							
B 3272	Martin's Calf Feed	Union City G.*	......	26.0	6.0	6.0	....	Cottonseed meal, linseed meal, gluten feed, germ middlings, wheat middlings, red dog flour, peanut oil meal, salt.
		F.*	10.2	25.0	6.9	7.1	5 00	
	The Quaker Oats Co., Chicago, Ill.							
B 2719	Schumacher Calf Meal	Hudson G.*	......	18.0	8.0	4.0	....	Cottonseed meal, wheat meal, ground flaxseed, milk albumen, bicarbonate of soda, oat meal.
		F.*	8.2	16.6	7.4	2.8	4 75	
B 2883	Schumacher Calf Meal	Reading	6.6	16.9	6.8	2.7	4 25	Oat meal, wheat, flaxseed meal, cottonseed meal, milk albumen bicarbonate of soda.
		Average	7.4	16.8	7.1	2.8	....	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Ralston Purina Co., St. Louis, Mo.								
B 3130	Purina Calf Chow Feed	Jamestown	G.*	......	33.0	4.0	3.5	....	Linseed meal, hominy feed, wheat flour, corn feed meal, blood flour.
			F.*	11.0	32.6	3.4	4.3	$6{40	
B 2845	Purina Calf Chow Feed	Port Huron		10.4	33.2	3.2	3.5	87{10	Linseed meal, corn meal, blood meal, ground flaxseed.
		Average		10.7	32.9	3.3	3.9	....	
	Ryde & Company, Chicago, Ill.								
B 1987	Ryde's Cream Calf Meal	Morenci	G.*	......	25.0	5.0	6.0	....	Cottonseed meal, hominy feed, blood meal, wheat *middlings*, ground flaxseed, beans and lentils, cocoa shell meal, salt, foenurgreek, anise, locust bean meal.
			F.*	10.9	25.1	5.5	8.4	....	
B 2483	Ryde's Cream Calf Meal	Grand Rapids		11.1	24.9	4.3	7.9	$77 00	Cottonseed meal, hominy feed, blood flour, ground flaxseed, wheat flour, cocoa shell meal, locust bean meal, beans and peas, foenurgreek, anise, salt.
B 2696	Ryde's Cream Calf Meal	St. Joseph		10.6	24.2	5.1	7.9	....	Same as B 2483.
B 2946	Ryde's Cream Calf Meal	Bay City		9.5	24.5	4.5	8.6	4 50	Same as B 2483.
B 3279	Ryde's Cream Calf Meal	Tecumseh		12.3	24.3	5.5	6.2	4 50	Same as B 2483.
		Average		10.9	24.6	5.0	7.8	....	
	E. L. Wellman, Grand Rapids, Mich.								
B 3134	Wellman's Qualiteed Calf Meal	Kent City	G.*	......	18.0	8.0	4.0	....	Linseed meal, wheat meal, oat meal, ground flaxseed, milk albumen, bicarbonate of soda.
			F.*	9.3	16.3	7.7	3.2	....	
	F. I. Williams & Son, North Adams, Mich.								
B 3727	Williams Calf Meal	North Adams	G.*	......	18.0	3.0	7.0	....	Linseed meal, breakfast food by-products, blood meal (trace), anise, salt.
			F.*	10.2	19.3	2.3	3.3	$4 00	
	HOG MEALS								
	American Milling Co., Peoria, Ill.								
B 1921	Sucrene Hog Meal	Detroit	G.*	......	18.0	4.0	14.0	....	Linseed meal, corn, bl[illegible] meal, alfalfa meal, *corn feed* meal, molasses, palm kernel meal, salt.
			F.*	10.1	20.2	6.0	7.6	2 65	
	Blatchford Calf Meal Factory, Waukegon, Ill.								
B 3323	Blatchford's Pig Meal	Detroit	G.*	......	18.0	5.0	7.0	....	Cottonseed meal, linseed meal, malt sprouts, wheat flour, oat meal, corn meal, locust bean meal, rice polish, cocoa shell meal, crushed flaxseed, bloodmeal, anise, salt.
			F.	9.9	20.6	6.3	7.5	94 00	

	Hales & Edwards Co., Chicago, Ill.								
B 1976	Pioneer Hog Feed with dried buttermilk	Clinton	G.*	......	12.0	3.0	12.0	....	Linseed meal, wheat middlings, corn feed meal, dried buttermilk, screenings.
			F.*	11.4	13.3	4.3	6.3	....	
B 2610	Pioneer Hog Feed with dried buttermilk	Holland		10.7	14.5	4.3	6.7	76 00	Linseed meal, alfalfa meal, wheat middlings, corn feed meal, buckwheat bran, dried buttermilk, grain screenings.
B 3070	Pioneer Hog Feed with dried buttermilk	Zeeland		10.7	14.4	4.5	8.2	65 00	Corn feed meal, wheat middlings, linseed meal, wheat, barley and kaffir screenings, dried buttermilk.
		Average		10.9	14.1	4.4	7.1	....	
	International Sugar Feed Co., Minneapolis, Minn.								
B 2735	International Hog Feed 6 per cent charcoal	Mason	G.*	......	22.5	5.0	12.0	....	
			F.*	11.9	22.8	5.0	12.3	$3 75	Linseed meal, wheat middlings, grain screenings, tankage, molass charcoal, salt
B 2902	International Hog Feed 6 per cent charcoal	Albion		10.4	20.9	5.8	14.9	3 40	Same as B 2735.
		Average		11.2	21.9	5.4	13.6	....	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
B 2530	Krause Hog Feed	Zeeland	G.*	......	15.0	5.9	9.0	....	Alfalfa meal, hominy feed, wheat, wheat bran, wheat middlings, oats, corn feed meal, corn germ meal, digester tankage.
			F.*	11.3	15.7	5.6	7.4	$70 00	
B 2596	Krause Hog Feed	Holland		9.8	14.8	5.7	7.5	68 00	Alfalfa meal, wheat bran and middlings, hominy feed, corn germ meal, corn feed meal, digester tankage, salt.
B 2642	Krause Hog Feed	Allegan		10.0	15.6	5.7	7.2	72 00	Alfalfa meal, wheat bran and middlings, with screenings, hominy feed, corn germ meal, corn feed meal, corn bran, digester tankage, salt.
B 2852	Krause Hog Feed	Deckerville		10.6	16.0	6.2	6.6	2 90	Same as B 2596.
B 3064	Krause Hog Feed	Zeeland		10.1	17.0	5.4	8.0	70 00	Same as B 2596.
B 3249	Krause Hog Feed	Adrian		10.9	16.6	6.0	10.8	3 15	Same as B 2596.
		Average		10.5	16.0	5.8	7.9	....	
	Purina Mills Branch, Ralston Purina Co., St. Louis, Mo.								
B 2783	Purina Pig Chow	Ann Arbor	G.*	......	14.0	5.2	9.0	....	Alfalfa meal, corn feed meal, corn bran, digester tankage, charcoal, molasses, salt.
			F.*	10.0	16.3	4.3	12.1	$60 00	
B 2844	Purina Pig Chow	Pt. Huron		10.0	17.1	4.2	9.6	59 60	Alfalfa meal, hominy feed, corn bran, blood meal, blood charcoal, *molasses, salt.*
B 2972	Purina Pig Chow	Birch Run		11.7	16.1	2.6	11.6	2.90	Alfalfa meal, corn feed meal, tankage, peat, molasses, salt.
		Average		10.6	16.5	3.7	11.1	....	
	The Quaker Oats Co., Chicago, Ill.								
B 3109	Big Pig Hog Feed	Cadillac	G.*	......	14.5	4.5	9.0	....	Oat middlings, oat shorts, oat hulls, corn feed meal, hominy feed, linseed meal, gluten feed, wheat middlings, ground barley, palm kernel oil meal, flax screenings, calcium phosphate, salt.
			F.*	4.8	12.9	3.7	11.7	$58 00	
B 3328	Big Pig Hog Feed	Elkton		9.6	13.4	3.4	13.1	....	Same as B 3109.
		Average		7.2	13.2	3.6	12.4	....	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	E. L. Wellman, Grand Rapids, Mich.								
B 3062	Wellman's Qualiteed Hog Feed	Grand Rapids	G.*	......	13.5	4.0	13.0	....	Linseed meal, gluten feed, hominy feed, oat *shorts*, oat *middlings*, oat hulls, palm kernel meal, corn feed meal, ground barley, wheat *middlings*, salt.
			F.*	9.4	13.1	3.5	12.8	$55 00	
B 3135	Wellman's Qualiteed Hog Feed	Fremont		9.3	13.3	3.9	12.2	60 00	Linseed meal, gluten feed, hominy feed, corn feed meal, wheat middlings, oat middlings, oat shorts, oat hulls, ground barley, calcium phosphate, salt.
B 3221	*Wellman's Qualiteed Hog Feed*	Almont		10.1	12.6	3.0	13.0	60 00	Linseed meal, gluten feed, hominy feed, corn feed meal, wheat *middlings*, *oat middlings*, oat shorts, oat hulls, ground barley, palm kernel meal, flax screenings, calcium phosphate, salt.
		Average		9.6	13.0	3.5	12.7	....	
	DAIRY AND STOCK FEEDS.								
	Amendt Milling Co., Monroe, Mich.								
B 2798	Amco Dairy Feed	Monroe	G.*	......	22.0	5.0	13.0	....	Cottonseed meal, linseed meal, gluten feed, brewers grains, distillers grains, malt sprouts, wheat bran and *middlings*, *corn feed*.
			F.*	8.9	24.4	4.7	8.3	....	
B 2805	*Amco Dairy Feed*	Trenton		8.8	24.8	5.9	9.2	$55 00	Same as B 2798.
B 2890	Amco Dairy Feed	Ypsilanti		8.8	*24.3*	*6.0*	*10.0*	*62 00*	*Same as* B 2798.
		Average		8.8	24.5	5.5	9.2	....	
	American Milling Co., Peoria, Ill.								
B 1913	Amco Dairy Feed	Detroit	G.*	......	25.0	8.0	16.0	....	Cottonseed meal, gluten feed, corn distillers grains, screenings, salt.
			F.*	9.5	24.4	6.4	14.6	$2 75	
B 1969	Amco Dairy Feed	Morenci		7.2	29.1	6.6	8.1	56 00	Gluten feed, distillers grains, oat hulls, clipped oat by-product, salt.
B 2492	Amco Dairy Feed	Grand Rapids		8.5	26.1	5.7	*16.9*	*62 00*	Brewers *grains*, *corn distillers* grains, oat hulls, salt.
B 2536	Amco Dairy Feed	Grandville		8.3	25.8	5.8	13.1	54 00	Cottonseed meal, gluten feed, corn distillers grains, oat clippings palm kernel meal, wheat (trace), salt.
		Average		8.4	26.4	6.1	13.2	....	
B 1911	Amco Stock Feed	Detroit	G.*	......	10.0	3.5	*9.0*	....	
			F.*	7.7	12.6	5.3	16.7	$2 50	Cottonseed meal, corn gluten feed, oat shorts.
B 1992	Empire State Dairy Feed	Morenci	G.*	......	30.0	10.0	14.0	....	
			F.*	6.7	29.7	11.2	12.2	59 00	Distillers grains.
	Arcady Farms Milling Co., Chicago, Ill.								
B 2545	Arcady Certified Dairy Feed	Jamestown	G.*	......	25.0	4.5	12.0	....	Cottonseed meal, linseed meal, gluten feed, brewers grains, malt sprouts, wheat bran and middlings, corn feed meal, *ground oats*, corn oil cake meal, salt.
			F.*	9.3	26.7	5.0	12.1	55 00	
B 3148	Arcady Certified Dairy Feed	Berlin		9.6	22.4	5.7	13.9	*63 00*	*Same as* B 2545.
		Average		9.5	24.6	5.4	13.0	....	

	J. J. Badenoch Co., Chicago, Ill.							
B 3269	Badenoch's Stock Feed	Constantine ... G.*	......	8.0	3.0	12.0	......	Oat shorts, oat middlings, oat hulls, hominy feed, corn feed meal, salt
		F.*	8.7	9.9	3.9	12.2	$3 25	
	Bad Axe Grain Co., Bad Axe, Mich.							
B 3827	Axe Brand Ground Feed	Bad Axe ... G.*	......	9.6	3.3	6.1	......	
		F.*	12.2	11.9	2.9	6.4	3 00	Wheat, oats and grain screenings.
	J. E. Bartlett Co., Jackson, Mich.							
B 2847	Farmer Brand Dairy Feed	Sandusky ... G.*	......	25.0	7.0	10.0	......	Cottonseed meal, brewers grains, wheat bran and middlings, grain screenings.
		F.*	8.7	24.3	5.1	10.8	2 75	
	Chapin & Company, Hammond, Ind.							
B 1971	Unicorn Dairy Ration	Tecumseh ... G.*	......	26.0	5.5	11.0	......	Cottonseed meal, linseed meal, gluten feed, gluten meal, hominy feed, brewers grains, corn distillers grains, malt sprouts wheat bran, barley feed, corn starch by-product, salt.
		F.*	8.9	27.4	5.9	11.3	59 00	
B 2485	Unicorn Dairy Ration	Coopersville	9.0	25.5	6.9	10.7	59 00	Same as B 1971.
B 2537	Unicorn Dairy Ration	Coopersville	8.4	27.8	5.6	10.3	59 00	Same as B 1971.
B 2573	Unicorn Dairy Ration	N. Muskegon	8.3	26.6	5.5	10.1	60 00	Same as B 1971.
B 2729	Unicorn Dairy Ration	Hillsdale	8.4	27.2	5.4	9.5	2 85	Same as B 1971.
B 2733	Unicorn Dairy Ration	Mason	9.4	26.1	5.4	9.2	3 00	Same as B 1971.
B 2744	Unicorn Dairy Ration	Leslie	9.5	26.4	5.0	9.6	3 00	Same as B 1971.
B 3016	Unicorn Dairy Ration	Mt. Pleasant	7.9	24.4	6.8	10.3	62 00	Same as B 1971.
		Average	8.8	26.4	5.8	10.1	......	
	The Albert Dickinson Co., Chicago, Ill.							
B 3095	Dickinson Dairy Feed	Muskegon ... G.*	......	24.0	5.5	11.0	......	Cottonseed meal, linseed meal, gluten feed, hominy feed, brewers grains, wheat bran and middlings, salt.
		F.*	9.0	23.8	5.1	11.0	$64 00	
B 3114	Dickinson Dairy Feed	Traverse City	9.6	23.8	5.0	10.7	61 00	Same as B 3095 with corn feed meal.
B 3284	Dickinson Dairy Feed	Kalamazoo	9.5	23.9	5.5	10.8	2 95	Same as B 3114.
		Average	9.4	23.8	5.2	10.8	......	
B 2645	Stag Stock Feed	Allegan ... G.*	......	9.0	3.0	12.0	......	
		F.*	9.8	8.5	3.3	11.6	$47 50	Wheat middlings, oat middlings, oat shorts, oat hulls, corn feed meal, corn bran, corn screenings, barley, salt.
B 2701	Stag Stock Feed	Adrian	10.2	10.2	3.6	9.5	2 75	Cottonseed meal, corn feed meal, corn bran, oat hulls oat shorts, oat middlings.
B 3270	Stag Stock Feed	Sturgis	10.2	8.9	4.2	10.7	3 25	Oat shorts, oat middlings, oat hulls, ground barley, cottonseed meal, corn feed meal, corn bran, salt.
		Average	10.1	9.2	3.7	10.6	......	
B 2488	White Cross Stock Feed	Grand Rapids ... G.*	......	10.0	3.5	10.0	......	
		F.*	11.2	10.4	4.4	6.5	$68 00	Cottonseed meal, wheat, oats, corn feed meal, corn bran, salt.
B 3644	White Cross Stock Feed	Allegan	11.6	10.4	4.2	5.5	68 00	Wheat middlings, oats, corn feed meal, corn bran, salt.
		Average	11.4	10.4	4.3	6.0	......	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Dixie Mills Company, St. Louis, Mo.								
B 2898	Anchor Dairy Feed	Albion	G.*		24.0	4.0	12.0		Brewers grains, alfalfa meal, wheat bran and middlings, corn feed meal, cottonseed meal, linseed meal, gluten meal, salt.
			F.*	9.0	25.9	5.1	12.6	$2 90	
	The Famabella Co., Inc., Detroit, Mich.								
B 3313	Famabella Dairy Feed	Detroit	G.*		16.0	13.3	14.1		Cottonseed meal, alfalfa meal, wheat bran and middlings, ground peas, peanut hulls, grain screenings, oat hulls, corn bran.
			F.*	9.7	15.6	7.4	12.0	52 00	
	Feed Products Milling Co., Chicago, Ill.								
B 2503	Eatall Feeds Dairy Feed	Grand Rapids	G.*		25.0	4.0	15.0		Cottonseed meal, linseed meal, gluten feed, brewers grains, malt sprouts, wheat bran, corn feed meal.
			F.*	9.8	25.6	3.6	12.5	59 00	
B 2607	Eatall Feeds Dairy Feed	Holland		8.1	26.3	3.8	13.3	63 00	Same as B 2503.
		Average		9.0	26.0	3.7	12.9		
B [illegible]58	Polo Stock Feed	Battle Creek	G.*		10.0	2.5	9.0		Gluten feed, wheat bran and middlings, crushed oats, oat shorts and middlings, oat hulls, corn feed meal.
			F.*	10.8	10.5	3.3	7.4	$60 00	
	Hales & Edwards Co., Chicago, Ill.								
B 1975	Golden Flake Dairy Feed	Clinton	G.*		16.0	3.5	15.0		Cottonseed meal, linseed meal, gluten feed, molasses, clipped oat by-product, screenings, salt.
			F.*	10.1	17.0	2.8	13.9		
B 2758	Pioneer Stock Feed	Lansing	G.*		10.0	2.5	9.0		Corn feed meal, oat middlings, oat shorts, oat hulls, crushed oats gluten feed, wheat bran and middlings.
			F.*	11.5	13.1	3.5	8.2	3 50	
B 2760	Pioneer Stock Feed	Lansing		11.8	12.6	3.3	7.4	3 50	Same as B 2758.
B 3215	Pioneer Stock Feed	Homer		11.6	12.8	3.6	7.7	3 50	Same as B 2758
		Average		11.6	12.8	3.5	7.8		
B 1974	Red Horn Dairy Feed	Clinton	G.*		25.0	4.0	15.0		Cottonseed meal, linseed meal, gluten feed, brewers grains, malt sprouts, wheat bran, weed seeds.
			F.*	9.7	26.0	3.9	12.1		
B 2588	Red Horn Dairy Feed	Holland		8.8	26.5	4.8	11.6	$60 00	Same as B 1974, corn feed meal, salt.
B 2664	Red Horn Dairy Feed	Battle Creek		9.2	27.3	4.3	12.7	57 00	Cottonseed meal, linseed meal, brewers grains, malt sprouts, wheat bran, corn meal, grain screenings.
B 3116	Red Horn Dairy Feed	Petoskey		9.1	23.9	4.2	12.5	67 00	Cottonseed meal, linseed meal, gluten feed, brewers grains, malt sprouts, alfalfa meal, wheat bran, corn feed meal.
		Average		9.2	25.9	4.3	12.2		
	Interstate Feed Association, Detroit, Mich.								
B 2992	Mohrcream Dairy Feed	Milford	G.*		21.0	6.0	10.5		Distillers grains, oat shorts, oat middlings, oat hulls, corn feed meal, hominy feed, gluten feed, cottonseed meal, linseed meal, wheat bran and middlings, salt.
			F.*	10.3	22.6	4.6	10.5		

	Chas. A. Krause Milling Co., Milwaukee, Wis.							
B 3065	Badger Dairy Feed	Zeeland ... G.*	......	19.0	3.5	15.0	......	Cottonseed meal, linseed meal, gluten feed, hominy feed, brewers grains, wheat bran and middlings, oat shorts, oat middlings, oat hulls, corn germ meal, salt.
		F.*	9.0	21.6	3.6	13.0	$58 00	
B 1980	*Badger Stock Feed*	*Clinton* ... G.*	......	10.0	4.5	12.0	......	
		F.*	9.2	9.9	4.5	11.8	55 00	Oat shorts, oat hulls, corn feed meal.
B 2616	**Badger Stock Feed**	Wayland	9.8	9.1	4.1	**14.4**	65 00	Wheat bran and middlings, oats, corn, grain screenings.
B 2739	**Badger Stock Feed**	Mason	8.8	9.1	**3.9**	**14.7**	3 00	Hominy feed, corn bran, oat shorts and middlings, oat hulls, corn germ meal, salt.
B 3211	Badger Stock Feed	Otsego	9.8	10.0	**3.8**	**14.3**	2 90	Same as B 2739.
		Average	9.4	9.5	4.1	13.8	......	
B 2853	Cream City Dairy Feed	Deckerville ... G.*	......	19.0	3.5	15.0	......	Cottonseed meal, linseed meal, gluten feed, brewers grains, wheat bran and middlings, oat shorts, oat middlings, oat hulls, salt.
		F.*	8.4	19.6	4.4	14.6	$2 60	
B 3290	Cream City Dairy Feed	Otsego	8.7	18.3	3.9	**16.5**	2 90	Same as B 3290, corn germ meal.
		Average	8.6	19.0	4.2	15.6	......	
B 2468	Krause Dairy Feed	Coopersville ... G.*	......	24.0	5.0	13.0	......	Cottonseed meal, linseed meal, gluten feed, brewers grains, corn distillers grains, malt sprouts, wheat bran and middlings with screenings, corn germ meal, salt.
		F.*	10.0	24.8	5.1	12.8	$55 00	
B 2474	Krause Dairy Feed	Grand Rapids	9.3	25.2	5.5	12.6	57 00	Same as B 2468.
B 2529	Krause Dairy Feed	Zeeland	9.6	**21.7**	**3.9**	13.2	59 00	Same as B 2468.
B 2540	Krause Dairy Feed	Zeeland	9.1	28.0	5.5	9.9	54 00	Cottonseed meal, gluten feed, brewers grains, corn distillers grains malt sprouts, wheatbran and middlings with mill run screenings, hominy feed, corn germ meal.
B 2578	Krause Dairy Feed	Sparta	9.0	23.7	5.1	11.1	58 00	Cottonseed meal, linseed meal, gluten feed, hominy feed, brewers grains, corn distillers grains, malt sprouts, wheat bran and middlings with mill run screenings, corn germ meal, salt.
B 2738	Krause Dairy Feed	Mason	8.9	25.2	5.1	12.7	3 00	Same as B 2540.
B 2750	Krause Dairy Feed	St. Johns	9.3	25.2	5.5	9.3	65 00	Same as B 2540.
B 2850	Krause Dairy Feed	Deckerville	9.1	24.7	5.8	10.1	2 00	Same as B 2578, no corn germ meal nor salt.
B 2913	Krause Dairy Feed	Sturgis	13.1	24.1	5.8	11.3	2 90	Same as B 2578.
B 2918	Krause Dairy Feed	Owosso	9.3	25.4	5.5	11.1	2 75	Same as B 2578.
B 3066	Krause Dairy Feed	Zeeland	8.8	26.1	5.6	10.3	64 00	Same as B 2578.
		Average	9.6	24.9	5.3	11.3	......	
B 2752	Krause Stock Feed	St. Johns ... G.*	......	10.0	4.5	12.0	......	Hominy feed, corn germ meal, corn flour, oat shorts, oat middlings, oat hulls, salt.
		F.*	10.1	10.7	6.8	8.6	$58 00	
B 2577	Krause Stock Feed	Sparta	9.4	9.9	5.6	11.4	59 00	Hominy feed, corn germ meal, oat middlings, oat shorts, oat hulls, corn, *maize red dog flour*.
B 2851	Krause Stock Feed	Deckerville	8.2	8.8	6.5	11.2	2 70	Same as B 2752.
		Average	9.2	9.8	6.3	10.4	......	
B 2560	Pep Feed	Muskegon ... G.*	......	10.0	3.5	16.0	......	Alfalfa meal, hominy feed, cracked corn, wheat, oats, oat hulls.
		F.*	8.9	10.7	4.3	12.0	$65 00	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Larrowe Milling Co., Detroit, Mich.								
B 1929	Larro-Feed	Detroit	G.*	......	20.0	3.0	14.0	......	Cottonseed meal, gluten meal, corn distillers' grains, dried beet pulp, wheat middlings, wheat bran and screenings, salt.
			F.*	9.3	21.3	4.5	11.9	$2 75	
B 1981	Larro-Feed	Clinton		9.9	21.0	4.5	11.6	56 00	Same as B 1929.
B 2513	Larro-Feed	Grand Rapids		9.5	20.4	4.2	11.6	2 70	Same as B 1929.
B 2523	Larro-Feed	Grandville		9.5	21.3	3.6	11.5	2 70	Same as B 1929.
B 2534	Larro-Feed	Zeeland		10.0	22.6	4.2	11.4	55 00	Same as B 1929.
B 2553	Larro-Feed	Muskegon		10.1	21.6	4.2	11.6	56 00	Same as B 1929.
B 2778	Larro-Feed	Lansing		9.2	21.4	4.0	12.3	3 00	Same as B 1929.
		Average		9.7	21.4	4.2	11.7	......	
B 1925	Larrowe Big Six Dairy Feed	Detroit	G.*	......	21.0	4.0	12.0	......	Cottonseed meal, linseed meal, corn gluten feed, wheat bran, wheat middlings with ground screenings, corn distillers grains, hominy feed, salt.
			F.*	9.9	21.6	5.6	8.4	$2 75	
B 2506	Larrowe Big Six Dairy Feed	Grand Rapids		9.8	21.3	5.4	8.2	60 00	Same as B 1925.
B 2532	Larrowe Big Six Dairy Feed	Zeeland		9.9	20.8	5.5	8.5	58 00	Same as B 1925.
B 2705	Larrowe Big Six Dairy Feed	Adrian		9.4	21.0	6.0	9.2	55 00	Same as B 1925.
		Average		9.8	21.2	5.6	8.6	......	
	McMorran Milling Co., Port Huron, Mich.								
B 2840	Protean Feed	St. Clair	G.*	......	20.0	3.0	12.0	......	Linseed meal, gluten feed, wheat bran and middlings, pea bran, salt.
			F.*	9.4	14.4	2.9	20.3	$52 00	
B 2848	Protean Feed	Sandusky		9.3	12.8	2.4	25.3	2 65	Linseed meal, gluten feed, wheat bran and middlings, oats, pea bran, wheat screenings.
		Average		9.4	13.6	2.7	22.8	......	
	Omaha Alfalfa Milling Co., Omaha, Nebr.								
B 2987	Beauty Dairy Feed	Durand	G.*	......	24.0	3.0	20.0	......	Alfalfa meal, wheat bran, cottonseed meal, linseed meal, corn meal.
			F.*	9.7	20.6	3.8	15.7	$58 00	
B 3066	Beauty Dairy Feed	Grand Rapids		8.9	19.7	3.8	17.4	58 00	Same as B 2987, salt.
		Average		9.3	20.2	3.8	16.6	......	
	Park & Pollard Co., Chicago, Ill.								
B 3068	Stevens 44 Dairy Ration	Grand Rapids	G.*	......	24.0	5.0	14.0	......	Cottonseed meal, linseed meal, gluten feed, hominy feed, brewers grains, distillers grains, wheat bran and middlings, buckwheat middlings, ground barley, corn meal, coconut oil meal, pea meal, corn germ meal, salt.
			F.*	10.1	23.7	6.4	9.0	$63 00	

	Quaker Oats Co., Chicago, Ill.								
B 2587	Big Q Dairy Ration	Vriesland	G.*	......	21.0	8.0	10.0	....	Cottonseed meal, linseed meal, gluten feed, hominy feed, corn distillers grains, wheat bran and middlings and screenings, oat meal by-products, salt.
			F.*	8.9	21.9	5.3	11.8	$56 00	
B 2909	Big Q Dairy Ration	Constantine		10.0	21.9	5.0	10.3	3 00	Same as B 2587.
B 2928	Big Q Dairy Ration	Morrice		9.7	20.4	5.5	10.9	58 00	Same as B 2587.
B 2952	Big Q Dairy Ration	Bay City		9.2	22.3	5.0	11.1	3 00	Same as B 2587.
B 3007	Big Q Dairy Ration	Sunfield		8.6	21.4	5.2	11.1	60 00	Same as B 2587.
B 3015	Big Q Dairy Ration	Alma		8.3	23.2	5.0	10.2	58 00	Same as B 2587.
B 3030	Big Q Dairy Ration	Shepherd		9.8	21.9	5.2	11.8	57 00	Same as B 2587.
B 3248	Big Q Dairy Ration	Adrian		10.6	21.8	5.3	12.4	2 75	Oat shorts, oat middlings, oat hulls, wheat bran and middlings, hominy feed, cottonseed meal, linseed meal, distillers grains, calcium phosphate, salt.
B 3254	Big Q Dairy Ration	Ann Arbor		10.5	21.3	5.8	12.3	63 40	Same as B 2587.
		Average		9.5	21.8	5.3	11.3	....	
B 3282	Max-All Corn Feed	Jackson	G.*	......	8.0	1.4	2.0	....	Hominy feed, *crushed oat groats, cooked corn grits*, toasted corn products.
			F.*	4.4	8.4	1.6	1.1	$2 70	
B 2834	Schumacher F. S. Feed	Kalamazoo	G.*	......	10.0	3.2	10.0	....	Cottonseed meal, hominy feed, wheat flour, wheat middlings, oat shorts, oat hulls, corn, corn feed meal, barley, ground puffed rice, salt.
			F.*	9.3	12.2	3.9	11.1	60 00	
B 2834	Schumacher F. S. Feed	Port Huron		9.6	11.0	3.6	10.4	58 00	Hominy feed, corn feed meal, oat shorts, oat hulls, barley, wheat flour, wheat middlings, salt.
B 2854	Schumacher F. S. Feed	Deckerville		9.2	11.5	4.2	10.7	2 75	Cottonseed meal, hominy feed, corn feed meal, wheat flour and middlings, oat shorts, *oat middlings, oat hulls, barley, puffed* wheat and rice, salt.
B 3025	Schumacher F. S. Feed	Clare		9.2	11.9	4.6	10.4	55 00	Same as B 2854.
		Average		9.3	11.7	4.1	10.7	....	
B 2864	Sterling Feed	Jackson	G.*	......	9.2	3.2	8.0	....	Cottonseed meal, hominy feed, corn feed meal, oat shorts, oat middlings, oat hulls, wheat middlings, puffed wheat, puffed rice, salt.
			F.*	9.2	11.7	4.1	10.5	$2 70	
	Smith Parry Co., Milwaukee, Wis.								
B 2614	Wisconsin Vitex Dairy Feed	Wayland	G.*	......	24.0	6.0	11.0	....	Cottonseed meal, linseed meal, gluten feed, gluten meal, hominy feed, brewers grains, corn distillers grains, malt sprouts, wheat bran, corn germ meal, grain screenings, salt.
			F.*	9.2	26.5	5.5	10.9	59 00	
B 2623	Wisconsin Vitex Dairy Feed	Marshall		7.6	25.8	5.7	12.7	60 00	Cottonseed meal, gluten feed, brewers grains, distillers grains, malt sprouts, wheat bran, charcoal, salt, grain screenings.
B 2688	Wisconsin Vitex Dairy Feed	Watervliet		8.8	26.0	5.5	10.5	60 00	Cottonseed meal, gluten meal, hominy feed, brewers grains, distillers grains, malt sprouts, wheat bran, salt.
B 2831	Wisconsin Vitex Dairy Feed	Bad Axe		8.1	26.3	5.7	11.2	3 00	Same as B 2614.
B 2835	Wisconsin Vitex Dairy Feed	Saginaw		8.8	26.0	5.7	11.1	3 00	Cottonseed meal, gluten feed, brewers grains, distillers grains, malt sprouts, wheat bran and middlings, linseed meal, salt.
B 3002	Wisconsin Vitex Dairy Feed	Greenville		7.8	27.8	5.8	10.8	....	Cottonseed meal, gluten feed, hominy feed, brewers grains, distillers grains, malt sprouts, wheat bran and middlings, corn oil meal, salt.
B 3043	Wisconsin Vitex Dairy Feed	Cedar Springs		9.9	25.2	5.9	11.8	54 00	Cottonseed meal, linseed meal, hominy feed, brewers grains, distillers grains, malt sprouts, wheat bran, gluten meal, gluten feed, corn oil meal, salt.
		Average		8.6	26.2	5.7	11.2	....	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	The Ubiko Milling Co., Cincinnati, Ohio.								
B 2793	Union Grains Biles Ready Dairy Ration	Ann Arbor	G.*	......	24.0	7.0	10.0	....	Cottonseed meal, linseed meal, gluten feed, hominy feed, brewers grains, distillers grains, malt sprouts, wheat bran and middlings, salt.
			F.*	8.4	25.1	5.7	10.5	$2 90	
B 2808	Union Grains Biles Ready Dairy Ration	Ann Arbor		7.8	24.8	6.7	11.5	58 00	Same as B 2793.
		Average		8.1	25.0	6.2	11.0	....	
	Wagner White Co., Jackson, Mich.								
B 2906	Wawco Dairy Feed	Constantine	G.*	......	26.0	5.0	14.0	....	Hominy feed, alfalfa meal, wheat bran, ground oats, corn meal, gluten feed, cottonseed meal, linseed meal, salt.
			F.*	9.8	21.3	4.3	10.0	....	
B 2101	Wawco Dairy Feed	Coopersville		9.6	26.0	6.0	10.5	$60 00	Hominy feed, wheat bran, middlings, ground oats, linseed meal, gluten feed, cottonseed meal, salt.
		Average		9.7	23.7	5.2	10.3	....	
B [illegible]108	Golden Cream Dairy Feed	Vriesland	G.*	......	20.0	3.5	14.0	....	Cottonseed meal, linseed meal, gluten feed, hominy feed, oat feed, wheat bran, salt.
			F.*	8.9	21.4	4.7	16.4	$55 00	
	E. L. Wellman, Grand Rapids, Mich.								
B 3220	Wellman's Qualiteed Dairy Feed	Almont	G.*	......	21.0	6.0	10.5	....	Oat shorts, oat middlings, oat hulls, wheat bran and middlings, cottonseed meal, linseed meal, gluten feed, distillers grains, salt.
			F.*	10.5	21.9	5.1	10.9	62 00	
B 3240	Wellman's Qualiteed Dairy Feed	Mason		10.2	22.4	5.1	11.1	3 00	Same as B 3220 with hominy feed.
B 3304	Wellman's Qualiteed Dairy Feed	Leslie		9.4	22.4	4.9	11.3	3 00	Same as B 3240.
		Average		10.0	22.3	5.0	11.1	....	
	Western Products Co., Hammond, Ind.								
B 3256	Calumet Dairy Feed	Allegan	G.*	......	20.0	4.6	14.8	....	Clipped oat by-products, grain screenings, cottonseed meal, gluten feed, brewers grains, wheat bran, corn meal, salt.
			F.*	19.8	19.6	4.9	12.8	$3 10	
	MOLASSES DAIRY AND STOCK FEEDS.								
	American Milling Co., Peoria, Ill.								
B 1932	Amco Fat Maker	Detroit	G.*	......	10.0	3.5	12.0	....	Distillers grains, oats, oat hulls, corn, molasses, salt.
			F.*	8.7	16.1	3.6	11.0	2 40	
B 2491	Amco Fat Maker	Grand Rapids		9.7	14.2	3.8	10.3	57 00	Distillers grains, oats, oat hulls, cracked corn, clipped oat by-product, molasses.
		Average		9.2	15.2	3.7	10.7	....	

B 1916	Sucrene Dairy Feed	Detroit	G.*	......	16.5	3.5	14.0	......	Cottonseed meal, brewers grains, molasses, alfalfa meal, oat hulls, salt.
			F.*	9.0	17.0	4.1	15.0	$2 50	
B 1988	Sucrene Dairy Feed	Morenci		9.4	18.0	4.6	13.9	47 00	Cottonseed meal, gluten feed, distillers grains, oat hulls, molasses, ground and bolted grains, clipped oat by-product, salt.
B 2494	Sucrene Dairy Feed	Grand Rapids		9.7	19.3	5.0	**15.9**	50 00	Cottonseed meal, gluten feed, corn distillers grains, clipped oat by-product, grain screenings, molasses, salt.
B 2522	Sucrene Dairy Feed	Grandville		8.7	16.9	3.8	**16.8**	......	Same as B 2494.
B 2581	Sucrene Dairy Feed	Kent City		9.2	18.6	4.7	14.6	55 00	Same as B 2494.
B 2706	Sucrene Dairy Feed	Adrian		8.8	18.2	4.5	**15.1**	47 00	Same as B 2494.
B 2791	Sucrene Dairy Feed	Ann Arbor		9.2	17.8	3.6	**15.7**	......	Same as B 2494 with *palm kernel meal.*
B 2812	Sucrene Dairy Feed	Grass Lake		9.1	19.6	4.1	**16.2**	48 00	Same as B 2791.
		Average		9.3	18.1	4.3	**15.4**	......	
	Arcady Farms Milling Co., Chicago, Ill.								
B 2544	Arcady Dairy Feed	Holland	G.*	......	16.0	3.5	15.0	......	Cottonseed meal, gluten meal, brewers grains, malt sprouts, grain screenings, oat clippings, molasses, salt, cocoa shell meal.
			F.*	10.9	18.9	4.7	13.9	$45 00	
B 2707	Arcady Dairy Feed	Adrian		8.0	14.5	3.4	16.0	48 00	Same as B 2544, without cocoa shell meal.
B 2718	Arcady Dairy Feed	Hudson		9.5	18.0	4.0	14.9	48 00	Same as B 2707.
B 2749	Arcady Dairy Feed	St. Johns		12.6	18.9	3.4	12.9	50 00	Same as B 2544.
B 2784	Arcady Dairy Feed	Lansing		10.1	17.8	4.3	15.7	46 00	Same as B 2544.
		Average		10.2	17.6	4.0	14.7	......	
	Bad Axe Grain Co., Bad Axe, Mich.								
B 2528	Molasses Feed	Bad Axe	G.*	......	9.9	1.5	19.2	......	Wheat, *corn, oats, cocoa shell meal*, molasses, salt.
			F.*	17.0	9.7	1.5	10.0	......	
	J. E. Bartlett Co., Jackson, Mich.								
B 3258	Farmer Brand Molasses Ration	Jackson	G.*	......	16.0	5.5	16.0	......	Oat shorts, oat middlings, oat hulls, grain screenings, cottonseed meal, distillers grains, palm kernel meal, molasses, salt.
			F.*	13.2	17.6	4.3	14.5	$2 30	
	Hales & Edwards Co. Chicago, Ill.								
B 2695	Greeno Feed	St. Joseph	G.*	......	10.0	0.5	26.0	......	
			F.*	16.3	12.4	1.2	18.1	......	Alfalfa meal, oats, corn, molasses.
B 2728	Greeno Feed	Hillsdale		15.9	15.1	0.7	16.2	2 30	Alfalfa meal, molasses.
		Average		16.1	13.8	1.0	17.2	......	
	Interstate Feed Association, Detroit, Mich.								
B 2656	Mormilk Ready Ration Dairy Feed	Battle Creek	G.*	......	20.0	4.5	15.0	......	Cottonseed meal, clipped oat by-product, grain screenings, molasses salt.
			F.*	10.1	19.7	4.9	15.2	$52 00	
B 2690	Mormilk Ready Ration Dairy Feed	Benton Harbor		9.6	19.5	5.5	**19.8**	50 00	Same as B 2656.
B 2774	Mormilk Ready Ration Dairy Feed	Lansing		10.6	**18.3**	**3.8**	**17.1**	3 00	Same as B 2656.
B 2788	Mormilk Ready Ration Dairy Feed	Ann Arbor		11.5	19.2	5.4	15.3	2 65	Same as B 2656, with oat hulls.
B 2810	Mormilk Ready Ration Dairy Feed	Milan		9.5	19.6	5.3	17.0	52 00	Same as B 2656.
B 2816	Mormilk Ready Ration Dairy Feed	Vassar		9.5	20.4	5.5	15.8	2 75	Same as B 2656.
B 2820	Mormilk Ready Ration Dairy Feed	Cass City		9.7	**18.8**	4.3	**18.9**	50 00	Same as B 2656.
B 2874	Mormilk Ready Ration Dairy Feed	Williamston		9.5	20.6	5.4	14.8	52 00	Same as B 2656, with linseed meal.
B 2939	Mormilk Ready Ration Dairy Feed	Bay City		11.3	**18.7**	4.7	15.9	2 70	Same as B 2656.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified
	Interstate Feed Association, Detroit Mich.—Con								
B 2940	Mormilk Ready Ration Dairy Feed	Gladwin		10.7	20.8	5.4	15.1	$2 80	Same as B 2874.
B 3094	Mormilk Ready Ration Dairy Feed	*Muskegon*		*9.1*	*18.9*	*5.5*	*18.6*	*56 00*	Same as B 2656.
B 3122	Mormilk Ready Ration Dairy Feed	Ithaca		10.0	19.4	4.8	14.2	......	Same as B 2874
B 3155	Mormilk Ready Ration Dairy Feed	Holland		12.7	19.9	6.0	13.4	50 25	Same as B 2656.
B 3211	Mormilk Ready Ration Dairy Feed	Webberville		6.6	19.9	4.3	15.1	55 00	Same as B 2874.
B 3217	Mormilk Ready Ration Dairy Feed	Eaton Rapids		10.7	20.4	5.2	15.5	53 00	Same as B 2874.
B 3222	Mormilk Ready Ration Dairy Feed	Romeo		10.7	20.6	5.7	15.3	58 00	Same as B 2874.
B 3243	Mormilk Ready Ration Dairy Feed	Mason		11.4	20.1	5.4	12.5	2 85	Same as B 2874.
B 3252	Mormilk Ready Ration Dairy Feed	Adrian		11.8	20.9	6.1	15.4	2 80	Same as B 2874.
		Average		10.3	19.8	5.2	15.6	......	
	International Sugar Feed Co., Minneapolis, Minn.								
B 2428	International Cattle Planters Feed	Kalamazoo	G*	......	22.0	3.5	18.5	......	
			F*	10.4	21.9	3.4	20.2	$50 00	Cottonseed meal, ground cottonseed hulls, molasses, salt.
B [illegible]70	International Special Dairy Feed	Tecumseh	G*	......	*15.0*	*4.5*	*14.0*		
			F*	10.5	13.9	4.3	20.4	48 00	Cottonseed meal, clipped oat by-product, screenings, molasses.
B 2736	International Special Dairy Feed	Mason		11.6	14.4	3.8	14.1	3 00	Cottonseed meal, clipped oat by-product, grain screenings, molasses.
B 2893	International Special Dairy Feed	Saline		10.2	14.9	5.3	17.5	2 50	Same as B 2736, with salt.
B 2899	*International Special Dairy Feed*	*Albion*		*9.5*	*13.8*	*4.2*	*18.4*	*2 40*	*Same as B 2893.*
B 2984	International Special Dairy Feed	Lapeer		9.7	14.3	4.6	18.5	50 00	Same as B 2893.
B 3106	International Special Dairy Feed	Jamestown		11.6	14.7	4.9	17.2	43 00	Same as B 2893.
		Average		10.5	14.3	4.5	17.7	......	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
B 3087	Sweet Cud Dairy Feed	Otsego	G*	......	14.0	1.2	20.0	......	
			F*	14.5	14.1	1.5	19.7	$50 00	Alfalfa meal, cottonseed meal, molasses, salt.
B 3131	Sweet Cud Dairy Feed	Jamestown		16.1	13.0	1.6	23.9	52 00	Same as B 3087.
		Average		15.3	13.6	1.6	21.8	......	
	Lichtenberg & Son, Detroit Mich.								
B 1950	Faramel Dairy Feed	Detroit	G*	......	23.0	4.0	12.0	......	
			F*	9.3	23.4	6.3	3.8	$52 00	Cottonseed meal, gluten feed, brewers grains, distillers grains, malt sprouts wheat bran, oat hulls, molasses, weed seeds.
B 2813	Faramel Dairy Feed	Vassar		7.9	24.2	5.7	13.5	56 00	Cottonseed meal, gluten feed, brewers grains, distillers grains, malt sprouts, wheat bran, oat feed, salt, molasses.
B 2983	Faramel Dairy Feed	Flint		7.6	23.6	5.5	12.5	3 00	Same as B 2813.
B 2993	Faramel Dairy Feed	Milford		*9.9*	*21.8*	*5.0*	*12.6*	*62 00*	*Same as B 1950.*
		Average		8.7	23.3	5.6	10.6	......	

	Omaha Alfalfa Milling Co., Omaha, Nebr.								
B 2602	*Cream Alfalfa Dairy Feed No. 1*	Holland	G.*	......	20.0	3.0	18.0	......	
			F.*	8.8	19.8	2.8	15.3	58 00	Cottonseed meal, *alfalfa meal, wheat bran, corn, molasses.*
B 2563	Green Meadow Dairy Feed	Muskegon	G.*	......	11.0	1.6	25.0	......	
			F.*	16.3	13.0	0.8	18.2	49 00	Alfalfa meal, molasses.
B 2968	Green Meadow Dairy Feed	Durand		16.9	9.5	0.9	15.0	45 00	*Alfalfa meal, oats, corn, molasses.*
		Average		16.6	11.3	0.9	16.6	......	
	The Quaker Oats Co., Chicago, Ill.								
B 2586	Blue Ribbon Dairy Feed	Vriesland	G.*	......	25.0	5.0	14.0	......	*Cottonseed meal,* linseed meal, hominy feed, corn distillers grains, wheat bran with ground screenings, oat meal by-products, oat hulls, corn feed meal, salt, molasses.
			F.*	9.1	22.0	5.1	13.6	$56 00	
B 2797	Blue Ribbon Dairy Feed	Mt. Clemens		9.1	23.6	5.4	12.5	2 70	*Same as B 2586 with calcium phosphate.*
B 2355	Blue Ribbon Dairy Feed	Ann Arbor		9.1	23.7	5.5	14.5	2 90	Oat shorts, oat middlings, oat hulls, wheat bran and middlings, cottonseed meal, gluten feed, hominy feed, distillers grains, corn feed meal, calcium phosphate, molasses, salt.
		Average		9.1	23.1	5.3	13.5	......	
B 2516	Quaker Dairy Feed	Grand Rapids	G.*	......	16.0	5.5	16.0	......	Clipped out by-product, grain screenings, distillers grains, linseed meal, molasses, salt.
			F.*	9.0	15.5	4.0	18.2	$47 00	
B 2989	Quaker Dairy Feed	Morrice		10.2	14.8	3.7	14.8	......	Oat shorts, oat middlings, oat hulls, distillers grains, cottonseed meal, palm kernel meal, calcium phosphate, molasses, salt.
B 3289	Quaker Dairy Feed	Otsego		11.6	18.0	5.0	11.8	2 70	Same as B 2989 with grain screenings.
		Average		10.3	16.1	4.2	14.9	......	
	Ralston Purina Co., St. Louis, Mo.								
B 2785	Purina Cow Chow Feed	Ann Arbor	G.*	......	24.0	4.5	13.5	......	Cottonseed meal, gluten feed, brewers grains, alfalfa meal, clipped oat by-products, molasses.
			F.*	9.5	24.6	3.8	13.4	$58 00	
B 2971	Purina Cow Chow Feed	Birch Run		10.0	26.9	3.3	12.8	2 90	Same as B 2785 without clipped oat by-product.
		Average		9.8	25.8	3.6	13.1	......	
B 2842	Purina Fatena Feed	Port Huron	G.*	......	12.0	2.5	10.0	......	Alfalfa meal, corn, grain screenings, cottonseed meal, peat, molasses, salt.
			F.*	15.6	12.7	2.0	10.0	$56 10	
B 2841	Purina Omolene Feed	Port Huron	G.*	......	9.7	3.2	8.0	......	
			F.*	10.9	10.5	3.9	7.5	67 00	Alfalfa meal, oats, corn, molasses.
B 2786	Good Luck Feed with Molasses	Ann Arbor	G.*	......	9.0	1.5	15.0	......	
			F.*	14.6	10.4	2.7	11.6	60 00	Alfalfa meal, cracked corn, oats, molasses, salt.
	E. L. Wellman, Grand Rapids, Mich.								
B 3034	Feeders Favorite Dairy Feed	Cadillac	G.*	......	16.0	5.5	16.0	......	Clipped oat by-product, grain screenings, palm kernel meal, cottonseed meal, salt.
			F.*	12.3	15.9	4.9	12.8	$52 00	
B 3055	Feeders Favorite Dairy Feed	Grand Rapids		11.6	15.8	4.5	14.3	48 00	Cottonseed meal, distillers grains, palm kernel meal, clipped oat by-product, oat middlings, oat shorts, oat hulls, grain screenings, molasses, salt.
B 3162	Feeders Favorite Dairy Feed	Remus		12.9	16.4	4.8	13.0	53 00	Cottonseed meal, distillers grains, palm kernel oil meal, oat shorts, oat middlings, oat hulls, grain screenings, molasses, calcium phosphate, salt.
B 3305	Feeders Favorite Dairy Feed	Leslie		11.7	17.1	4.1	13.8	2 75	Same as B 3162.
		Average		12.1	16.1	4.6	13.5	......	

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Western Grain Products Co., Hammond, Ind.								
B 2473	Hammond Dairy Feed	Grand Rapids	G.*	......	16.5	3.5	12.0	......	Cottonseed meal, corn distillers grains, malt sprouts, cocoa shell meal, ground grain screenings, clipped oat by-product.
			F.*	9.1	15.8	4.1	15.8	$43 00	
B 2580	Hammond Dairy Feed	Kent City		9.8	16.5	4.9	13.8	55 00	Cottonseed meal, malt sprouts, alfalfa meal, oat hulls, barley cocoa shell meal, grain screenings, molasses.
B 2615	Hammond Dairy Feed	Wayland		9.3	15.2	3.9	15.6	51 00	Cottonseed meal, clipped oat by-products, oat hulls, grain screenings, cocoa shell meal, molasses, salt.
B 2684	Hammond Dairy Feed	Bangor		9.3	16.7	5.4	12.7	52 00	Cottonseed meal, distillers grains, malt sprouts, clipped oat by-product, grain screenings, molasses, salt.
B 2686	Hammond Dairy Feed	Hartford		9.4	13.9	4.3	16.4	50 00	Same as B 2615.
B 2877	Hammond Dairy Feed	Grand Ledge		11.4	18.9	4.5	15.1	2 50	Same as B 2684.
B 3006	Hammond Dairy Feed	Mulliken		8.3	16.1	3.9	17.7	50 00	Same as B 2615.
B 3037	Hammond Dairy Feed	Big Rapids		10.5	16.3	4.2	14.9	50 00	Same as B 2615.
B 3285	Hammond Dairy Feed	Allegan		10.2	15.8	4.4	15.6	2 60	Same as B 2615.
		Average		9.7	16.1	4.4	15.3	......	
	HORSE FEEDS.								
	J. J. Badenoch Co., Chicago, Ill.								
B 2916	Kurvnek Horse Feed	Coldwater	G.*	......	9.5	2.5	5.0	......	
			F.*	10.3	10.7	4.8	7.2	3 50	Corn, crushed oats, ground barley.
B 3110	Kurvnek Horse Feed	Cadillac		10.9	9.9	4.4	7.9	78 00	Corn, oats, barley.
		Average		10.6	10.3	4.6	7.6	......	
	Albert Dickinson Co., Chicago, Ill.								
B 2665	White Cross Horse Feed	Battle Creek	G.*	......	10.0	2.5	8.0	......	
			F.*	10.5	11.9	3.7	7.5	$65 00	Crushed oats, cracked corn.
	Farnabella Co., Detroit, Mich.								
B 3209	Common Sense Horse Feed	Rochester	G.*	......	9.7	3.5	6.0	......	
			F.*	10.7	10.4	3.3	13.8	3 40	Alfalfa meal, ground oats, corn and barley.
	Hales & Edwards Co., Chicago, Ill.								
B 2762	Excelsior Horse Feed	Lansing	G.*	......	10.0	3.0	8.0	......	Cracked corn, rolled oats.
			F.*	10.3	10.5	4.1	7.3	3 75	
B 3295	Excelsior Horse Feed	Kalamazoo		11.3	10.4	4.6	6.3	4 00	Same as B 2762.
		Average		10.8	10.5	4.4	6.4	......	

	Larrowe Milling Co., Detroit, Mich.								
B 2879	Log Cabin Horse Feed	Grand Ledge	G.*	......	10.0	3.0	15.0	....	
			F.*	9.7	10.9	3.7	14.1	$3 50	Alfalfa meal, cracked corn, wheat bran, oats, dried beet pulp.
	Quaker Oats Co., Chicago, Ill.								
B 2881	Schumacher Special Horse Feed	Jackson	G.*	......	9.2	3.2	8.0	....	
			F.*	10.3	9.6	3.4	7.9	2 40	Corn, oats, oat shorts, oat middlings, oat hulls, salt.
B 3228	Schumacher Special Horse Feed	Birmingham		9.8	10.0	3.4	9.2	3 20	Oats, oat shorts, oat middlings, oat hulls, corn meal, salt.
		Average		10.1	9.8	3.4	8.6	....	
B 2807	White Diamond Horse Feed	Grand Rapids	G.*	......	8.0	3.2	9.0	....	
			F.*	10.8	9.8	3.4	6.3	$65 00	Hominy feed corn feed meal, oat middlings, oat hulls, grain screenings.
B 2569	White Diamond Horse Feed	Muskegon		10.0	9.1	2.7	8.5	79 00	Hominy feed, corn feed meal, oat middlings, oat hulls, salt.
B 2970	White Diamond Horse Feed	Birch Run		11.5	9.4	3.4	8.9	3 00	Hominy feed, corn, corn feed meal, oat shorts, oat middlings, oat hulls, grain screenings, calcium phosphate, salt.
B 3229	White Diamond Horse Feed	Birmingham		11.1	8.4	3.0	7.3	3 20	Hominy feed, ground corn and kaffir, calcium phosphate, salt.
		Average		10.9	9.2	3.1	7.8	....	
	E. L. Wellman, Grand Rapids, Mich.								
B 3059	Wellman's Qualiteed Horse Feed	Grand Rapids	G.*	......	8.0	3.5	9.0	....	
			F.*	10.0	9.6	3.7	8.9	$62 00	Oat middlings, oat shorts, oat hulls, hominy feed, corn meal, calcium phosphate, salt.
B 3219	Wellman's Qualiteed Horse Feed	Almont		11.7	7.9	2.8	7.5	65 00	Oat middlings, oat shorts, oat hulls, hominy feed, corn feed meal, cracked corn, calcium phosphate.
B 3241	Wellman's Qualiteed Horse Feed	Mason		12.4	8.9	2.9	8.4	....	Same as B 3219, with salt.
B 3306	Wellman's Qualiteed Horse Feed	Leslie		12.0	7.7	3.0	7.9	3 25	Same as B 3241.
		Average		11.5	8.5	3.1	8.2	....	
	MOLASSES HORSE FEEDS.								
	American Milling Co., Peoria, Ill.								
B 1910	Peoria Horse Feed	Detroit	G.*	......	10.0	2.5	14.0	....	
			F.*	14.3	9.9	2.8	13.9	$2 90	Alfalfa meal, oats, corn, molasses, salt.
B 1909	Sucrene Horse Feed with Alfalfa	Detroit	G.*	......	10.0	2.5	12.0	....	
			F.*	14.3	10.5	3.0	12.2	3 00	Alfalfa meal, oats, corn, barley, molasses, salt.
B 3622	Sucrene Horse Feed with Alfalfa	Detroit		13.5	10.4	3.1	11.8	65 00	Alfalfa meal, corn, oats, grain screenings, molasses, salt.
		Average		13.9	10.5	3.1	12.0	....	
B 3327	Tip Top Horse Feed with Alfalfa	Birmingham	G.*	......	10.0	2.5	12.0	....	
			F.*	14.6	10.1	2.9	13.5	$4 50	Alfalfa meal, oats, corn, distillers grains, molasses, salt.
	Acady Farms Milling Co., Chicago, Ill.								
3146	Country Gentlemen Horse Feed	Hudsonville	G.*	......	9.0	2.0	15.0	....	
			F.*	13.6	11.5	2.1	14.4	63 00	Alfalfa meal, corn, oats, molasses.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	J. J. Badenoch Co., Chicago, Ill.								
B 2699	Glosscoat Horse Feed	Greenville	G.*	......	10.0	2.0	12.0	....	
			F.*	11.0	11.3	3.9	7.7	$70 00	Alfalfa meal, corn, oats, molasses.
	Albert Dickinson Co., Chicago, Ill.								
B 1877	Hobby Horse Feed	Detroit	G.*	......	9.0	1.5	15.0	....	
			F.*	13.3	11.5	1.8	12.2	2 90	Alfalfa meal, oats, corn, molasses.
B 2502	Hobby Horse Feed	Grand Rapids		14.3	11.8	2.3	12.7	62 00	Same as B 1877.
B 2552	Hobby Horse Feed	Muskegon		14.5	12.2	1.7	13.5	60 00	Same as B 1877.
		Average		14.0	11.8	1.9	12.8	....	
B 1906	Oasis Horse Feed	Detroit	G.*	......	9.0	1.5	15.0	....	
			F.*	13.2	12.6	2.8	12.5	$3 25	Alfalfa meal, oats, corn, molasses, salt.
	Feed Products Milling Co., Chicago, Ill.								
B 1958	Kingfalfa Horse Feed	Detroit	G.*	......	10.0	2.0	15.0	....	*Alfalfa meal, oats molasses*
			F.*	8.8	13.5	2.8	11.1	2 75	
	Grain Belt Milling Co., St. Joseph, Mo.								
B 2318	Pennant Horse and Mule Feed	Detroit	G.*	......	10.0	1.0	18.0	....	
			F.*	15.1	10.0	1.3	14.4	....	Alfalfa meal, corn, oats molasses salt
	Hales & Edwards Co., Chicago, Il.								
B 2588	Harvest Horse Feed	Holland	G.*	......	10.0	2.0	15.0	....	
			F*	13.6	13.0	2.0	10.0	60 00	Alfalfa meat, corn, oats, barley, molasses.
B 2663	Harvest Horse Feed	Battle Creek		10.0	12.2	2.6	12.8	58 00	Alfalfa meal, oats, cracked corn, molasses.
B 2757	Harvest Horse Feed	Lansing		13.5	15.1	3.0	13.8	3 25	*Alfalfa meal oats, cracked corn, barley, molasses.*
B 2761	Harvest Horse Feed	Lansing		15.9	12.1	1.7	13.0	3 25	Same as B 2663.
		Average		13.3	13.1	2.3	12.4	....	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
B 2561	Badger Horse Feed	Muskegon	G.*	......	10.0	2.0	12.0	....	
			F.*	13.6	10.9	2.3	12.9	$60 00	Alfalfa meal, oats, cracked corn, wheat screenings, molasses.
B 2776	Badger Horse Feed	Lansing		16.2	10.8	1.8	15.0	3 50	Alfalfa meal, oats, corn, molasses, salt.
B 2934	Badger Horse Feed	Owosso		18.4	11.0	1.9	12.6	2 85	Same as B2561.
B 3292	Badger Horse Feed	Otsego		13.4	10.3	2.2	16.1	3 25	Same as B 2776.
		Average		15.4	10.8	2.1	13.9	....	

B 1948	Blue Top Horse Feed	Detroit	G.*	......	10.0	1.0	16.0	......	
			F.*	15.8	11.3	1.9	15.3	47 00	Alfalfa meal oats, corn, molasses.
B 1882	Crescent Horse Feed	Detroit	G.*	......	10.0	1.5	18.0	......	
			F.*	13.2	9.6	2.8	14.0	2 60	Alfalfa meal, oats, oat hus, corn, molasses salt.
B 1967	Crescent Horse Feed	Detroit		11.6	10.3	2.3	15.4	2 60	Alfalfa meal, oats, corn, molasses, clipped oat by-products, salt.
		Average		12.4	10.0	2.5	14.7	......	
B 2528	Krauss Horse Feed	Zeeland	G.*	......	10.0	2.5	10.0	......	
			F.*	15.2	10.2	2.9	10.8	$60 00	Alfalfa meal, corn, oats, molasses, salt, weed seeds.
B 2923	Pul-Mor Horse Feed	Owosso	G.*	......	9.0	1.0	16.0	......	Alfalfa meal, cracked corn, oats, clipped oat by-product, molasses, salt
			F.*	17.7	11.1	1.7	13.1	2 60	
	Lichtenberg & Son Detroit, Mich.								
B 1952	Faramel Horse Feed	Detroit	G.*	......	10.0	3.0	10.0	......	Oats, molasses.
			F.*	13.2	10.8	4.3	10.9	54 00	
	New Century Co. Detroit, Mich.								
B 1688	New Century Horse Feed	Detroit	G.*	......	9.0	1.5	15.0	......	
			F.*	5.4	12.4	2.9	10.8	3 25	Alfalfa meal, oats, corn, molasses, salt.
B 3316	New Century Horse Feed	Detroit		13.5	10.0	2.4	11.1	65 00	Alfalfa meal, corn, oats, molasses.
		Average		9.5	11.2	2.7	11.0	......	
	Omaha Alfalfa Milling Co., Omaha, Nebr.								
B 1942	Al-Corn-O Horse Feed	Detroit	G.*	......	10.0	2.0	12.0	......	
			F.*	9.9	14.5	2.8	14.3	$44 00	Alfalfa meal, oats, corn, barley, molasses.
B 2564	Al-Corn-O Horse Feed	Muskegon		13.2	13.5	2.1	15.5	50 00	Alfalfa meal, corn, oats, molasses.
		Average		11.6	14.0	2.5	14.9	......	
B 7086	Alfalmo Feed	Durand	G.*	......	11.0	1.0	25.0	......	
			F.*	12.4	11.1	0.7	15.9	48 00	Alfalfa meal, molasses.
B 1946	Peerless Alfalmo Horse Feed	Detroit	G.*	......	10.0	2.0	12.0	......	
			F.*	11.1	13.5	2.5	15.3	47 00	Alfalfa meal, oats, molasses.
B 2406	Peerless Alfalmo Horse Feed	Grand Rapids		13.4	12.1	2.3	11.0	62 00	Alfalfa meal, oats, cracked corn, barley, molasses, salt.
B 2407	Peerless Alfalmo Horse Feed	Grand Rapids		14.2	12.9	2.0	15.1	55 00	Alfalfa meal, barley, oats, molasses, salt.
B 2560	Peerless Alfalmo Horse Feed	Muskegon		13.7	11.4	2.5	12.7	62 00	Alfalfa meal, corn, oats, molasses.
B 2808	Peerless Alfalmo Horse Feed	Holland		14.5	11.7	2.4	12.6	60 00	Same as B 2406
B 3113	Peerless Alfalmo Horse Feed	Traverse City		16.1	10.7	2.3	12.7	62 00	Alfalfa meal, cracked corn, oats, molasses, salt.
		Average		13.8	12.1	2.3	13.2	......	
	M. C. Peters Mill Co., Omaha, Nebr.								
B 1837	Peters Economy Horse Feed	Detroit	G.*	......	10.0	2.0	20.0	......	
			F.*	6.8	12.4	2.7	17.3	$3 60	Alfalfa meal, oats, molasses, salt.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Quaker Oats Co., Chicago, Ill.								
B 2908	Golden Sweet Mule Feed	Constantine	G.*	......	9.0	2.0	15.0	......	Alfalfa meal, oat shorts, oat middlings, oat hulls, cracked corn, cottonseed meal, molasses, salt.
			F.*	8.7	10.3	1.9	19.1	$2 90	
B 2510	Green Cross Horse Mixed Feed	Grand Rapids	G.*	......	10.0	2.5	12.0	......	Cottonseed meal, alfalfa meal, cracked corn, oats, wheat, oat meal by-products, salt, molasses.
			F.*	10.4	10.3	2.8	14.0	60 00	
B 2575	Green Cross Horse Mixed Feed	Sparta		9.4	11.5	2.6	13.0	65 00	Cottonseed meal, alfalfa meal, corn meal, oats, oat middlings, oat hulls, molasses, salt.
B 2635	Green Cross Horse Mixed Feed	Kalamazoo		9.4	11.3	2.7	12.6	70 00	Cottonseed meal, alfalfa meal, cracked corn, oat shorts, oat hulls, crushed oats, grain screenings, molasses, salt.
		Average		9.7	11.0	2.7	13.2	......	
	Western Grain Products Co., Hammond, Ind.								
B 2477	Calumet Alfalfa Horse Feed	Grand Rapids	G.*	......	10.0	2.5	15.0	......	Alfalfa meal, oats, corn, wheat, barley, molasses, salt.
			F.*	11.0	11.3	2.7	12.1	58 00	
B 3140	Calumet Alfalfa Horse Feed	Muskegon		10.7	11.5	3.0	15.1	66 00	Alfalfa meal, corn, oats, linseed meal, grain screenings, molasses, salt
		Average		10.9	11.4	2.9	13.6	......	
	POULTRY FEEDS.								
	Amendt Milling Co., Monroe, Mich.								
B 2799	Ameo Poultry Mash	Monroe	G.*	......	15.5	2.5	10.0	......	Gluten feed, meat scraps, alfalfa meal, wheat bran, wheat middlings, corn feed meal, oats (ground), charcoal, salt.
			F.*	9.9	20.1	3.6	7.9	......	
B 2891	Ameo Scratch Grains	Ypsilanti	G.*	......	9.5	2.4	4.3	......	Cracked corn, kaffir, wheat, oats, barley, buckwheat, linseed cake, sunflower, charcoal, grit, screenings, shell.
			F.*	12.3	10.6	3.3	3.7	4 63	
	American Milling Co., Peoria, Ill.								
B 1916	Cluck Cluck Scratch Feed	Detroit	G.*	......	10.0	2.5	5.0	......	Wheat, oats, corn, kaffir, buckwheat, barley, sunflower, weed seeds.
			F.*	11.8	11.1	3.9	4.0	4 00	
B 1935	Cluck Cluck Scratch Feed	Detroit		11.4	11.4	3.1	4.2	75 00	Same as B 1916.
B 1936	Cluck Cluck Scratch Feed with Grit	Detroit		10.7	12.3	3.3	4.0	72 50	Same as B 1916 with grit.
B 2027	Cluck Cluck Scratch Feed with Grit	Kalamazoo		11.5	11.8	2.8	4.1	81 00	Same as B 1916 with grit.
B 2859	Cluck Cluck Scratch Feed with Grit	Jackson		10.8	11.0	3.8	3.2	3 70	Same as B 1916 with grit.
		Average		11.1	11.5	3.4	4.7	......	
B 3321	Sucrene Pigeon Feed	Detroit	G.*	......	10.0	2.5	5.0	......	Cracked corn, kaffir, wheat, buckwheat, millet, peas, sunflower, grain screenings.
			F.*	13.0	10.3	3.0	3.7	$90 00	

B 1915	Sucrene Scratch Feed	Detroit	G.*	......	10.0	2.5	5.0	....	
			F.*	11.8	10.8	3.1	3.9	4 00	Wheat, oats, corn, kaffir, buckwheat, barley, sunflower, flax, wild buckwheat.
B 2872	Sucrene Scratch Feed	*Jackson*		11.3	10.9	3.5	3.7	3 90	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, weed *seeds*.
B 3224	Sucrene Scratch Feed	Birmingham		12.0	10.5	3.5	4.3	4 20	Same as B 2872.
B 2871	Sucrene Scratch Feed with Grit	Jackson		11.6	*11.1*	3.5	3.3	3 80	Same as B 2872 with grit.
		Average		*11.2*	10.8	3.4	3.8	....	
B 1939	Tip Top Scratch Feed	Detroit	G.*	......	10.0	2.5	5.0	....	
			F.*	11.1	12.4	3.3	5.4	$73 50	*Wheat, oats, corn*, kaffir, buckwheat, sunflower, weed seeds.
B 1938	Tip Top Scratch Feed *with Grit*	Detroit		10.7	11.9	3.1	5.0	71 00	Same as B 1939 with grit.
		Average		10.9	12.2	3.2	5.2	....	
	Arcady Farms Milling Co., Chicago, Ill.								
B 2720	Arcady Poultry Feed	Hudson	G.*	......	10.0	2.5	5.0	....	
			F.*	10.8	11.4	3.7	4.6	$4 25	*Cracked corn*, kaffir, wheat, oats, barley, buckwheat, sunflower, weed seeds.
B 3273	Arcady Poultry Feed	Quincy		*13.0*	*10.4*	3.4	5.0	....	Same as B 2720, no weed seeds.
		Average		11.9	10.9	3.6	4.8	....	
B 315	Atlantic Poultry Feed	Berlin	G.*	......	9.0	2.5	5.0	....	
			F.*	12.9	10.4	4.5	4.3	$85 00	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, recleaned wheat screenings, salvage grains.
	J. J. Badenoch Co., Chicago, Ill.								
B 3309	C-Er-Lay Fine Chick Feed	*Lansing*	G.*	......	9.5	2.5	5.0	....	
			F.*	11.7	8.9	2.7	*2.5*	*4 30*	*Cracked corn, kaffir*, wheat, oats, *millet, grit*.
B 2957	C-Er-Lay Poultry Feed	Lansing	G.*	......	9.5	2.5	5.0	....	
			F.*	*13.7*	*9.8*	3.4	3.3	4 00	Cracked corn, kaffir, wheat, oats barley sunflower, weed seeds.
B 2780	C-Er-Lay Poultry Feed with grit	Lansing		10.1	10.3	2.4	3.6	3 80	Same as B 2957 with grit and charcoal.
B 2781	C-Er-Lay Poultry Feed with Charcoal	Lansing		*11.8*	11.5	2.6	3.6	4 00	Cracked corn, kaffir, wheat, oats, barley, sunflower, charcoal.
		Average		11.9	10.5	2.8	4.5	....	
B 1965	Daily *Egg* Poultry *Feed*	Detroit	G.*	......	9.5	2.5	5.0	....	
			F.*	*11.7*	*11.9*	3.2	4.4	$4 00	Wheat, oats, corn, kaffir, barley, sunflower, milo, wild buckwheat.
B 2782	Daily Egg Poultry Feed	Lansing		10.8	12.6	2.8	4.7	3 80	Cracked corn, kaffir, wheat, oats, barley, *sunflower*, salvage wheat, weed seeds.
B 2926	Daily Egg Poultry Feed	*Perry*		11.2	10.2	3.3	3.7	....	Same as *B 2782 with grit*.
B 2958	Daily Egg Poultry Feed	Lansing		12.8	10.8	3.7	4.1	4 00	Same as B 2926.
B 2959	Daily Egg Poultry Feed	Lansing		11.8	10.4	3.6	3.8	3 85	Same as B 2926.
		Average		*11.7*	*11.2*	5.5	4.1	....	
B 2662	Eggs Pay Poultry Feed	*Muskegon*	G.*	......	9.5	2.5	5.0	....	
			F.*	10.7	11.5	3.5	5.3	$63 00	Cracked *corn*, kaffir, wheat, oats, barley, buckwheat, salvage wheat, sunflower, weed seeds, grit.
	Bad Axe Grain Co., Bad Axe, Mich.								
B 2629	Egg Brand Poultry Feed	Bad Axe	G.*	......	*10.0*	2.5	5.0	....	
			F.*	12.7	11.7	2.1	4.6	3 00	Wheat, barley, buckwheat, *rye, oats, screenings*.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Blatchford's Calf Meal Factory, Waukegan, Ill.							
B 1930	Blatchford's Fill the Basket Egg Mash	Detroit {G.* / F.*	...... / 9.7	19.0 / 19.6	4.0 / 4.9	10.0 / 10.2	...... / $3 50	Cottonseed meal, linseed meal, malt sprouts, meat scraps, bone meal, alfalfa meal, wheat flour, wheat bran and middlings, corn feed meal, blood flour, rice polish, cocoa shell meal, dried buttermilk, ground beans and peas, oatmeal, fish, unpressed flaxseed, cocoanut meal, locust bean meal, foenurgreek, anise salt.
B 3490	Blatchford's Fill the Basket Egg Mash	Grand Rapids	10.0	20.1	4.3	10.0	80.00	Same as B 1930.
		Average	9.9	19.9	4.6	10.1	....	
B 1931	Blatchford's Milk Mash	Detroit {G.* / F.*	...... / 9.2	20.0 / 20.9	4.0 / 4.6	7.5 / 7.8	...... / $3 75	Cottonseed meal, linseed meal, wheat flour, blood, flaxseed, barley and malt sprouts meal, ground beans and peas, cocoa shell meal, cocoanut meal, dried milk, locust bean meal, anise, foenurgreek, salt, bone, corn and oatmeal, beef scraps, fish, limestone, rice polish.
B 3240	Blatchford's Milk Mash	Adrian	9.3	20.2	5.8	6.7	4 00	Same as B 1931.
		Average	9.3	20.6	5.2	7.3	....	
	Caughey Jessman, Detroit, Mich.							
B 1891	CCC Scratch Feed	Detroit {G.* / F.*	...... / 11.7	9.5 / 11.6	2.5 / 2.5	2.5 / 3.6	...... / $76 00	Wheat, oats, rye, cracked corn, kaffir, buckwheat, barley, peas, wild buckwheat, weed seeds.
B 1892	CCC Scratch Feed	Detroit	12.1	11.4	2.7	2.9	76 00	Wheat, oats, cracked corn, kaffir, buckwheat, barley, millet, weed seeds, milo, grit.
		Average	11.9	11.5	2.6	3.3	....	
	F. B. Chamberlain, St. Louis, Mo.							
B 3180	Perfect Brand Chick Feed	Watervliet {G.* / F.*	...... / 9.7	10.0 / 13.2	2.5 / 3.1	5.0 / 4.2	...... / $6 00	Wheat, kaffir, grit, charcoal, milo maize, meat, bone, weed seeds, millet.
	The C. E. Conkey Co., Cleveland, Ohio.							
B 3280	Conkey's Buttermilk Starting Food for Baby Chicks	Tecumseh {G.* / F.*	...... / 11.5	12.0 / 13.9	3.0 / 2.4	4.0 / 3.2	...... / 7 00	Wheat, wheat middlings, hulled oats, ground corn, bone meal, dried buttermilk, gentian root, mustard seed.
	C. E. De Puy Co., Pontiac, Mich.							
B 3204	Peerless Scratch Feed	Pontiac {G.* / F.*	...... / 13.1	10.0 / 10.9	2.5 / 3.1	2.5 / 3.0	...... / 4 00	Cracked corn, kaffir, wheat oats, barley, rye, sunflower, salvage grains, milo, weed seeds.

	DeBoo & Co., Flint, Mich.								
B 2682	Peninsular Scratch Feed	Flint	G.*	......	10.0	2.5	5.0	......	Cracked corn, kaffir, wheat, *oats*, *barley*, buckwheat, sunflower,
			F.*	12.1	11.4	2.6	3.9	$4 30	weed seeds, grit.
	Albert Dickinson Co., Chicago, Ill.								
B 2267	Globe Chick Feed with Grit	Constantine	G.*	......	10.0	2.5	5.0	......	
			F.*	11.3	9.4	2.9	3.0	4 50	Cracked *corn*, *cracked* kaffir, millet, hulled oats, wheat screenings, grit.
B 1914	Globe Developing Feed	Detroit	G.*	......	10.0	2.5	5.0	......	
			F.*	12.6	10.6	3.5	2.9	4 00	Wheat, *hulled* oats, corn, kaffir, buckwheat, millet, weed seeds.
B 2268	Globe Developing Feed with Grit	Constantine		11.8	*8.7*	3.2	3.7	4 50	Grit, cracked corn, kaffir, wheat, rye, buckwheat, hulled oats, *millet*.
		Average		12.2	9.7	3.4	3.3	......	
B 1917	Globe Egg Mash	Detroit	G.*	......	15.0	3.0	10.0	......	
			F.*	11.1	*13.6*	*5.0*	6.6	$3 50	Linseed meal, meat scraps, alfalfa meal, wheat bran, middlings, *corn feed meal, corn *bran*, *salt*.
B 1909	Globe Egg Mash	Adrian		10.9	14.1	4.4	6.5	3 75	Same as B 1917 with oat shorts.
B 1897	Globe Egg Mash	Detroit		*10.4*	*15.2*	4.9	8.4	3 50	Same as B 1917.
B 2351	Globe Egg Mash	Muskegon Heights		10.9	15.1	4.5	7.5	80 00	Same as B 1917.
		Average		*10.8*	14.5	4.7	7.2	......	
B 1873	Globe Pigeon Feed	Detroit	G.*	......	*10.0*	*2.5*	5.0	......	
			F.*	12.6	11.4	3.3	4.2	$4 90	Wheat, peas, [buckwheat, kaffir, *millet*, *hemp*, *weed seeds*.
B 1896	Globe Pigeon Feed	Detroit		11.7	11.5	3.1	4.2	*5 00*	Wheat, *oats*, kaffir, buckwheat, barley, peas, millet, hemp.
	[illegible]	Average		12.2	11.5	3.2	4.2	......	
B 1899	Globe Scratch Feed	Detroit	G.*	......	10.0	2.5	5.0	......	
			F.*	11.6	10.6	2.5	3.2	$3 90	Wheat, oats, *oil cake*, *cracked* corn, kaffir, barley, sunflower.
B 1897	Globe Scratch Feed	Detroit		12.1	*11.3*	2.5	3.6	77 50	Same as B 1899.
B 2601	Globe Scratch Feed	Grand Rapids		12.5	10.7	2.7	3.5	83 00	Same as B 1899.
B 2681	Globe Scratch Feed	Zeeland		11.5	11.3	3.6	3.7	*80 00*	Same as B 1899 with grit and weed seeds.
B 2634	Globe Scratch Feed	Marshall		*10.2*	11.9	3.3	4.7	85 00	Same as B 1899 with grit and grain screenings.
		Average		11.6	11.1	2.9	3.7	......	
B 2500	Pine Tree Scratch Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	*12.5*	*10.9*	2.6	3.8	$82 00	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower.
B 2580	Pine Tree Scratch Feed	Muskegon Heights		12.1	10.9	3.0	4.2	85 00	Same as B 2500.
B 2779	Pine Tree Scratch Feed	Lansing		12.3	11.1	2.5	3.6	4 25	Same as B 2500.
B 3077	Pine Tree Scratch Feed	Grand Rapids		*13.4*	*10.9*	3.2	4.1	79 00	Same as B 2500.
B 3078	Pine Tree Scratch Feed with Grit	Grand Rapids		11.7	10.4	3.1	3.7	75 00	Same as B 2500 *with grit*.
		Average		*12.4*	10.8	3.1	3.9	......	
B 1872	Rival Scratch Feed	Detroit	G.*	......	*9.5*	2.5	5.0	......	
			F.*	12.6	12.2	2.7	4.0	$4 00	Wheat, oats, cracked corn, *kaffir*, *buckwheat*, *barley*.
B 2879	Rival Scratch Feed	Muskegon		10.7	10.4	*2.2*	3.9	*82 00*	Cracked corn, kaffir, wheat oats, barley, oil cake (trace), wild buckwheat and other weed seeds.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Albert Dickinson Co., Chicago, Ill.—*Con.*							
B 1900	Rival Scratch Feed with grit	Detroit	8.6	10.4	2.3	3.8	$3 85	Oats, wild buckwheat, cracked corn, kaffir, barley, grit.
B 3075	Rival Scratch Feed with grit	Grand Rapids	12.2	10.9	3.6	3.7	73 00	Same as B 1900 with weed seeds.
		Average	11.0	11.0	2.7	3.9	....	
B 1871	White Cross Scratch Feed	Detroit G.*	......	10.0	2.5	5.0	....	
		F.*	12.1	10.3	2.3	3.4	4 10	Wheat, oats, cracked corn, kaffir, barley, sunflower.
B 1912	White Cross Scratch Feed	Detroit	12.6	11.5	2.9	3.9	4 00	Same as B 1871 with buckwheat and weed seeds.
B 1940	White Cross Scratch Feed	Detroit	11.5	10.9	2.4	4.2	76 50	Same as B 1912.
B 2489	White Cross Scratch Feed	Grand Rapids	11.7	11.4	2.3	3.7	85 00	Same as B 1871.
B 1998	White Cross Scratch Feed with grit	Adrian	11.0	9.5	2.4	3.0	4 05	Wheat, oats, corn, kaffir, buckwheat, barley, weed seeds, grit.
		Average	11.8	10.7	2.5	3.6	....	
	Famabella Company, Detroit, Mich.							
B 1894	Famabella Common Sense Egg Mash	Detroit G.*	......	16.0	4.0	9.0	....	Linseed meal, alfalfa meal, wheat, wheat middlings, wheat bran, corn feed meal, kaffir, charcoal, weed seeds, salt.
		F.*	10.4	16.7	4.3	10.0	70 00	
B 3312	Famabella Common Sense Egg Mash	Detroit	9.6	16.1	7.5	11.2	70 00	Hominy feed, corn feed meal, grain screenings, peanut hulls, meat scrap, alfalfa meal, bone, wheat bran and middlings.
		Average	10.0	16.4	5.9	10.6	....	
B 3311	Famabella Common Sense Little Chick Feed	Detroit G.*	......	11.0	3.7	3.0	....	
		F.*	11.7	9.9	2.3	4.1	82 00	Cracked corn, kaffir, wheat, millet, weedseeds.
B 1893	Famabella Common Sense Pigeon Feed	Detroit G.*	......	15.0	2.5	4.0	....	
		F.*	12.0	12.4	2.2	3.2	89 00	Wheat, peas, milo, millet, weed seeds, kaffir, buckwheat.
B 1907	Famabella Common Sense Pigeon Feed	Detroit	12.1	13.2	2.4	2.7	5 00	Same as B 1893 without weed seeds.
		Average	12.1	12.8	2.3	3.0	....	
B 1895	Famabella Common Sense Scratch Feed	Detroit G.*	......	9.5	2.5	2.5	....	
		F.*	11.3	11.6	2.6	4.2	76 00	Wheat, oats, cracked corn, kaffir, buckwheat, barley, sunflower, weed seeds.
	Feed Products Milling Co., Chicago, Ill.							
B 2660	Golden Egg Scratch Feed	Battle Creek G.*	......	10.0	2.5	5.0	....	
		F.*	11.4	10.9	2.9	4.2	85 00	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower.
B 2759	Golden Egg Scratch Feed	Lansing	11.7	12.2	3.3	4.5	4 25	Same as B 2660.
		Average	11.6	11.6	3.1	4.4	....	

B 2661	Kuckoo Scratch Feed	Battle Creek	G.*	......	10.0	2.5	5.0	....	
			F.*	11.5	10.6	2.8	4.3	84 00	Cracked corn, kaffir, wheat, oats, barley, *sunflower*.
B 2606	Kuckoo Scratch Feed	Holland		11.2	10.8	2.9	4.2	83 00	Same as B 2661 with grit and screenings.
B 2663	Kuckoo Scratch Feed with grit	Battle Creek		11.2	10.8	2.6	4.2	82 00	Same as B 2661 with grit.
		Average		11.9	10.7	2.8	4.2	....	
	Hales & Edwards Co., Chicago, Ill.								
B 3154	Cackle Fine Chick Feed	Grand Rapids	G.*	......	9.0	2.0	7.0	....	
			F.*	13.6	8.6	2.5	1.3	4 75	Cracked corn, kaffir, wheat, millet, grit.
B 3300	Cackle Fine Chick Feed	Battle Creek		11.4	9.2	3.1	2.6	....	Same as B 3154 with charcoal.
		Average		12.5	8.9	2.8	2.0	....	
B 2472	Cackle Poultry Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	....	
			F.*	6.9	11.3	3.0	4.5	76 00	Cracked corn, kaffir, wheat, *oats*, *barley*, *sunflower*, *weed seeds*.
B 2770	Cackle Poultry Feed	Lansing		11.1	10.9	2.5	3.6	4 35	Same as B 2472 without weed seeds.
B 2548	Cackle Poultry Feed	Grand Haven		11.3	11.5	2.5	4.2	80 00	Same as B 2472 with grit.
B 2980	Cackle Poultry Feed	*Flint*		11.8	11.1	2.8	3.7	4 10	Same as B 2472 with grit.
		Average		10.3	11.2	2.7	4.0	....	
B 2555	Morning Glory Scratch Feed	Muskegon Hts	G.*	......	*10.0*	2.5	5.0	....	
			F.*	11.2	11.8	3.4	5.0	$80 00	Cracked corn, kaffir, wheat, oats, barley, sunflower, *millet*, *wild buckwheat*.
B 2766	*Morning Glory Scratch Feed*	Lansing		8.6	11.5	3.2	4.9	4 15	Cracked corn, *kaffir*, wheat, oats, barley, sunflower, wild buckwheat and *other* weed seeds.
B 2769	Morning Glory Scratch Feed	Lansing		10.6	11.2	3.0	4.7	3 95	Same as B 2766 with grit.
		Average		10.1	11.5	3.2	4.9	....	
B 1943	Red Comb Meat Mash with shell	Detroit	G.*	......	15.0	4.0	10.0	....	
			F.*	10.1	19.5	4 6	6.9	....	
B 2478	Red Comb Meat Mash with shell	*Grand Rapids*		10.2	14 2	3.9	6.4	$93 00	
		Average		10.2	16.9	4.3	6.7	....	
B 1973	Red Comb Poultry Feed	Clinton	G.*	......	*10.0*	2.5	5.0	....	
			F.*	12.5	10.4	2.6	3.6	....	Wheat, oats, cracked corn, kaffir, buckwheat, barley, sunflower.
B 2787	Red Comb Poultry Feed	Lansing		11.7	11.0	2.7	4.2	$4 40	Same as B 1973.
B 2471	*Red Comb Poultry Feed*	Grand Rapids		12.8	11.9	2.9	4.6	77 00	Same as B 1973 with weed seeds.
B 2554	Red Comb Poultry Feed	Muskegon Heights		12.4	*11.3*	*2.8*	*4.3*	*85 00*	*Same as* B 2471.
B 2549	Red Comb Poultry Feed	Grand Haven		11.9	11.0	2.8	3.5	80 00	Same as B 1973 with grit.
		Average		12.3	11.1	2.8	4.0	....	
	International Sugar Feed Co., Minneapolis, Minn.								
B 2737	International Poultry Feed Scratch Size	*Mason*	G.*	......	10.0	3.5	5.0	....	
			F.*	12.4	13.3	2.7	3.8	$4 25	Corn, kaffir, wheat, oats, *buckwheat*, barley, *linseed cake*, *sunflower*, weed seeds.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
B 2480	Blue Top Scratch Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	11.6	12.0	2.7	3.7	$77 00	Cracked corn, kaffir, wheat, oats, buckwheat, barley, sunflower, weed seeds.
B 2558	Blue Top Scratch Feed	Muskegon		11.7	12.4	2.5	3.5	86 00	Same as B 2480.
B 2595	Blue Top Scratch Feed	Holland		11.5	10.8	3.4	4.7	81 00	Same as B 2480.
B 3213	Blue Top Scratch Feed	Howell		12.0	12.4	2.7	3.5	4 50	Same as B 2480.
B 2594	Blue Top Scratch Feed	Holland		10.9	10.4	3.1	4.6	81 00	Same as B 2480 with grit.
B 3066	Blue Top Scratch Feed	Greenville		10.2	11.3	2.2	3.4	78 00	Same as B 2480 with grit.
		Average		11.3	11.6	2.8	3.9	......	
B 3163	Conservation Chick Feed	Holland	G.*	......	9.0	2.5	5.0	......	
			F.*	12.1	9.0	3.5	2.2	4 50	Cracked corn, kaffir, millet, grit.
B 3128	Conservation Scratch Feed	Jamestown	G.*	......	10.0	2.5	5.0	......	
			F.*	13.0	10.0	3.8	4.9	84 00	Cracked corn, kaffir, oats, buckwheat, barley, sunflower.
B 3233	Conservation Scratch Feed	Detroit		13.8	10.5	3.4	4.7	4 15	Same as B 3128 with weed seeds.
		Average		13.4	10.3	3.6	4.8	......	
B 3157	Krause Chick Feed	Otsego	G.*	......	10.0	2.5	5.0	......	
			F.*	12.0	9.9	4.0	2.1	$4 50	Cracked wheat, cracked corn, kaffir, milo maize, millet, grain screenings.
B 2556	Krause Mash	Muskegon	G.*	......	18.0	3.5	10.0	......	
			F.*	9.9	18.3	5.8	8.9	65 00	Hominy feed, alfalfa meal, wheat bran and middlings, red dog flour, corn feed meal, corn germ meal, meat scraps, salt.
B 3063	Krause Mash	Zeeland		10.3	17.1	5.2	6.4	78 00	Same as B 2556 without red dog flour and salt.
B 3374	Krause Mash	Detroit		10.6	18.5	5.1	6.7	3 40	Same as B 3063.
		Average		10.3	18.0	5.4	7.3	......	
	Larrowe Milling Co., Detroit, Mich.								
B 2521	Log Cabin Scratch Feed	Grand Rapids	G.*	......	10.0	2.5	6.0	......	
			F.*	12.1	11.9	3.7	4.5	$80 00	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, weed seeds.
B 2990	Log Cabin Scratch Feed	Fenton		12.6	11.5	4.4	3.7	4 75	Same as B 2521 with milo maize and no weed seeds.
B 3375	Log Cabin Scratch Feed	Tecumseh		12.7	9.4	3.3	5.7	4 50	Same as B 2990.
		Average		12.5	10.9	3.8	4.6	......	

	New Century Co. of Michigan, Detroit, Mich.								
B 1885	Cadillac Scratch Feed	Detroit	G.*	......	9.5	2.5	5.0	......	
			F.*	11.0	11.5	2.7	5.2	4 10	Wheat, oats, cracked corn, kaffir, buckwheat, barley.
B 1884	Cadillac Scratch Feed	Detroit		11.0	11.1	2.4	4.3	4 00	Same as B 1885 with flax, grit.
		Average		11.0	11.3	2.6	4.8	......	
B 1896	New Century Scratch Feed	Detroit	G.*	......	10.0	2.5	5.0	......	
			F.*	12.3	10.5	2.5	3.7	$4 30	Wheat, oats, cracked corn, kaffir, buckwheat, barley, sunflower.
	Oswego Milling Co., Oswego, N. Y.								
B 2977	Pontiac Scratch Feed	Flint	G.*	......	10.0	1.5	5.0	......	
			F.*	11.5	12.4	2.3	4.6	4 10	Cracked corn, kaffir, milo, wheat, oats, barley, buckwheat, salvage grains, flaxseed.
	Park & Pollard Co., Chicago, Ill.								
B 3112	Baby Buster Chick Feed	Cadillac	G.*	......	11.0	2.0	5.0	......	
			F.*	12.5	13.1	4.1	3.6	96 00	Cracked corn, wheat, kaffir, oats, millet, fish, meat.
B 3153	Baby Buster Chick Feed	Holland		13.9	16.0	4.7	2.5	4 60	Same as B 3112 with bone.
		Average		13.2	14.5	4.4	3.1	......	
B 1876	Growing Feeds	Detroit	G.*	......	10.0	1.5	8.0	......	
			F.*	10.9	11.9	3.2	8.0	$3 85	Dried beet pulp, wheat bran and middlings, wheat, oats, corn, oat hulls, corn bran, barley, buckwheat hulls, salt, clipped oat by-products, meat scraps, calcium carbonate.
B 1973	Growing Feed	Tecumseh		10.6	12.6	2.9	9.3	3 50	Beet pulp, meat scraps, bone, alfalfa meal, wheat bran and middlings with ground screenings, oats, corn meal, kaffir, buckwheat, barley, *salt, calcium carbonate.*
B 2514	Growing Feed	Grand Rapids		10.3	12.1	2.2	6.9	3 80	Dried beet pulp, meat scraps, alfalfa meal (trace), wheat, wheat bran and middlings, oats, corn, kaffir, buckwheat, barley, screenings, calcium carbonate, salt.
B 2058	Growing Feed	Bangor		9.9	16.1	4.2	7.5	80 00	Alfalfa meal, wheat, wheat bran and *middlings, oats, corn, kaffir,* buckwheat, barley, meat, bone, beet pulp, calcium carbonate, salt, glass, peat.
B 29	Growing Feed	Flint		9.9	13.3	3.8	8.7	3 75	*Alfalfa meal, wheat bran and* middlings, oat meal, corn, kaffir, buckwehat, barley, meat scraps, bone meal, blood, fish, marl.
B 3088	Growing Feed	Grand Rapids		10.9	13.9	3.7	7.2	80 00	Alfalfa meal, wheat bran and middlings, ground wheat, oats, corn, kaffir, buckwheat, barley, meat, bone, fish, marl, peat, glass.
		Average		10.4	13.3	3.3	7.9	......	
B 1868	Intermediate Chick Feed	Tecumseh	G.*	......	10.0	1.5	5.0	......	
			F.*	12.8	11.0	2.8	2.4	$4 25	Wheat, oats, *kaffir, cracked corn,* buckwheat, millet, marl.
B 1875	Lay or Bust Dry Mash	Detroit	G.*	......	18.0	1.5	12.0	......	
			F.*	10.0	16.0	3.4	9.4	3 75	Oat clippings, meat scraps, alfalfa meal, wheat bran and middlings, oat hulls, corn feed meal, corn bran, salt, glass, buckwheat hulls, calcium carbonate.
B 1967	Lay or Bust Dry Mash	Tecumseh		9.3	15.4	3.9	10.6	3 50	Meat scraps bone meal alfalfa meal, wheat bran and middlings oat hulls corn rice, fish, salt.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Park & Pollard Co., Chicago, Ill.,—Con.							
B 1995	Lay or Bust Dry Mash	Morenci	9.6	16.5	4.2	9.8	$3 75	Dried beet pulp, alfalfa meal, wheat, wheat middlings with mill run screenings, oats, corn, buckwheat, barley, fish scraps, calcium carbonate salt.
B 2505	Lay or Bust Dry Mash	Grand Rapids	9.9	17.4	3.6	8.5	100 00	Alfalfa meal, *wheat*, wheat bran and middlings, oats, corn, kaffir buckwheat, barley, fish, meat scraps, bone meal, grain screenings, calcium carbonate.
B 2620	Lay or Bust Dry Mash	Plainwell	9.4	17.1	3.8	10.2	70 00	Alfalfa meal, *wheat*, wheat bran and middlings, oats, corn, kaffir, buckwheat, barley, meat bone, beet pulp, fish, calcium carbonate, salt.
B 2640	Lay or Bust Dry Mash	Kalamazoo	9.0	16.3	3.9	9.7	80 00	Same as B 2620 with glass.
B 2682	Lay or Bust Dry Mash	Bangor	9.7	17.1	4.6	9.6	75 00	Same as B 2620.
B 2886	Lay or Bust Dry Mash	Plymouth	9.2	20.2	4.9	9.1	4 00	Alfalfa meal, wheat bran and middlings, oats, corn, meat scraps, dried beet pulp, fish, buckwheat, bran, marl, peat, coal, glass, calcium carbonate.
B 2917	Lay or Bust Dry Mash	Coldwater	8.9	20.6	4.8	7.5	3 75	Alfalfa meal, ground wheat, wheat bran and middlings, oat meal, corn meal, buckwheat, barley, meat scraps, bone meal, fish, marl, glass, peat, salt.
B 2981	Lay or Bust Dry Mash	Flint	9.4	16.6	4.0	9.1	3 75	Alfalfa meal, wheat bran, middlings, oats, corn, kaffir, buckwheat, barley meat, bone fish, glass, salt
B 3001	Lay or Bust Dry Mash	Greenville	9.0	20.2	5.0	8.0	....	Alfalfa meal, ground wheat, oats, corn, kaffir, buckwheat, barley, wheat bran and *middlings*, fish, meat, bone, marl, salt, peat, glass.
B 3014	Lay or Bust Dry Mash	Alma	10.0	16.9	2.5	5.6	60 00	Alfalfa meal, ground wheat, oats, corn, barley, kaffir, buckwheat, wheat bran, grain screenings marl, fish, salt.
B 3069	Lay or Bust Dry Mash	Zeeland	9.4	16.8	3.7	9.2	71 00	Same as B 3001 without glass.
B 3072	Lay or Bust Dry Mash	Grand Rapids	9.3	17.4	4.1	8.2	76 00	Same as B 3001.
B 3111	Lay or Bust Dry Mash	Cadillac	10.3	17.4	4.7	10.6	78 00	Same as B 3069 with blood.
		Average	9.5	17.5	4.0	9.0	....	
B 1966	Red Ribbon Scratch Feed	Tecumseh G.*	......	10.0	1.5	5.0	....	
		F.*	11.9	11.1	2.6	3.7	4.15	Wheat, oats, corn, kaffir, buckwheat, barley, sunflower, weed seeds.
B 1996	Red Ribbon Scratch Feed	Morenci	11.8	11.7	2.8	3.9	4 50	Same as B 1966 with milo.
B 2621	Red Ribbon Scratch Feed	Plainwell	11.9	11.1	2.4	4.1	85 00	Same as B 1996 with rye.
B 2639	Red Ribbon Scratch Feed	Kalamazoo	11.9	11.3	2.5	3.8	82 00	Same as B 2621.
B 2742	Red Ribbon Scratch Feed	Leslie	10.8	12.6	2.9	4.0	4 00	Same as B 1966 with weed seeds.
B 306	Red Ribbon Scratch Feed	Zeeland	11.0	11.3	4.2	4.5	82 00	Same as B 1966.
		Average	11.4	11.5	2.9	4.0	....	

B 1969	Screened Scratch Feed	Tecumseh	G.*	......	10.0	1.5	5.0	....	
			F.*	12.6	12.4	2.8	4.0	4 15	Wheat, oats, cracked corn, kaffir, buckwheat barley, milo, sunflower weed seeds.
B 3071	Screened Scratch Feed	Grand Rapids		11.5	11.3	3.7	4.4	80 00	Same as B 1969 without weed seeds.
		Average		12.1	11.9	3.3	4.2	....	
	Postum Cereal Co., Battle Creek, Mich.								
B 2649	Chicken Feed	Battle Creek	G.*	......	8.0	1.0	15.0	....	
			F.*	11.7	10.4	1.8	4.0	$50 00	Cracked corn, wheat (wheat screenings included), oats, rye, barley, weed seeds.
	Pratt Food Co., Chicago, Ill.								
B 3256	Pratts Baby Chick Feed	Ann Arbor	G.*	......	12.0	2.5	3.0	....	
			F.*	11.7	12.8	5.5	3.8	8 00	Corn meal, wheat middlings, oat middlings, ground rape,* millet, bone meal soluble starch, epsom salts, shell, black pepper.
B 3314	Pratts Baby Chick Feed	Detroit		11.0	13.0	4.4	4.2	8 00	Same as B 3256.
		Average		11.4	12.9	5.0	4.0	....	
	Quaker Oats Co., Chicago, Ill.								
B 2968	American Hen Scratch Grains	Birch Run	G.*	......	10.0	2.5	5.0	....	
			F.*	13.3	9.8	2.6	2.5	$4 50	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, weed seeds, grit.
B 2704	Pansy Scratch Grains	Ann Arbor	G.*	......	10.0	2.5	5.0	....	
			F.*	10.4	11.3	2.7	3.1	....	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, grit, weed seeds.
B 3159	Prize Winner Chick Feed	Three Rivers	G.*	......	10.0	2.5	5.0	....	
			F.*	12.9	11.0	4.4	2.4	4 85	Wheat, cracked corn, kaffir, charcoal, millet, oat meal, wild buckwheat, flaxseed, weed seed.
B 3167	Quaker Chick Feed	South Haven	G.*	......	10.0	2.5	5.0	....	
			F.*	12.5	10.4	4.8	3.0	....	Cracked wheat, cracked corn, kaffir, buckwheat, oat meal, millet, flaxseed, weed seeds, grit, charcoal.
B 2969	Schumacher Little Chick Feed	Birch Run	G.*	......	10.0	2.5	5.0	....	
			F.*	13.7	10.4	3.3	2.8	4 50	Cracked corn, kaffir, wheat, wild buckwheat, milo, millet, weed seeds, charcoal, grit.
	Ralston Purina Co., St. Louis, Mo.								
B 2846	Purina Chicken Chowder	Port Huron	G.*	......	19.0	4.0	9.0	....	
			F.*	10.4	20.3	4.5	7.8	3 65	Alfalfa meal, wheat bran, middlings, meat scraps, blood meal, linseed meal, charcoal, salt.
B 3126	Purina Chicken Chowder	Jamestown		10.1	18.5	4.4	9.5	84 00	Linseed meal, hominy feed, meat scraps, blood meal, alfalfa meal, wheat bran, middlings, corn feed meal, ground kaffir, charcoal, salt.
		Average		10.3	19.4	4.5	8.7	....	
B 3327	Purina Chick Feed	Harbor Beach	G.*	......	10.0	2.5	4.0	....	
			F.*	14.4	10.3	2.7	1.9	$4 50	Cracked corn, kaffir, milo wheat screenings, millet
B 2843	Purina Scratch Feed	Port Huron	G.*	......	10.0	2.5	4.0	....	
			F.*	11.2	11.4	3.6	3.5	4 00	Corn, kaffir, wheat, oats, barley, buckwheat, sunflower.
B 3127	Purina Scratch Feed	Jamestown		12.4	10.1	3.3	3.8	84 00	Same as B 2843 without oats
		Average		11.8	10.8	3.5	3.7	....	

***Abbreviations for Guaranteed and Found.**

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Russia Cement Co., Gloucester, Mass.								
B 2784	Chick Chuck Concentrated Poultry Feed	Lansing	G.*	......	50.0	2.0	1.9	....	
			F.*	7.2	51.8	1.1	1.7	$4 40	Fish.
	Saginaw Milling Co., Saginaw, Mich.								
B 2964	Red Hen Chick Starter	Saginaw	G.*	......	11.0	2.6	3.0	....	
			F.*	14.3	10.8	2.9	1.9	....	Cracked corn, kaffir, wheat, peas, millet, weed seeds.
B 2937	Red Hen Scratch Feed	Bay City	G.*	......	9.5	2.7	3.0	....	
			F.*	13.0	10.4	2.9	3.4	4 10	Wheat, oats, cracked corn, kaffir, buckwheat, barley, sunflower, weed seeds, ergot.
B 2967	Red Hen Scratch Feed	Saginaw		14.0	10.4	2.9	3.5	....	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, screenings.
B 2978	Red Hen Scratch Feed	Flint		12.0	11.1	2.4	2.9	4 10	Same as B 2937 without ergot and with grit.
		Average		13.0	10.6	2.7	3.3	....	
B 2966	Wolverine Scratch Feed	Saginaw	G.*	......	9.4	2.5	3.0	....	
			F.*	13.6	10.3	2.8	3.1	....	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower screenings.
	Scheuren & Mok, Detroit, Mich.								
B 3234	Eagle Scratch Feed	Detroit	G.*	......	10.8	3.3	3.5	....	
			F.*	14.5	9.5	3.7	4.8	$3 95	Corn, wheat, oats, barley, sunflower.
B 3235	Meat Mash	Detroit	G.*	......	19.0	4.6	10.1	....	
			F.*	11.3	17.8	4.8	9.7	3 50	Meat scraps, bone, blood, alfalfa, wheat bran and wheat middlings with mill run screenings, ground corn, salt.
	Standard Grocer & Milling Co., Holland, Mich.								
B 2533	Standard Scratch Feed	Holland	G.*	......	9.6	2.6	2.8	....	
			F.*	12.6	10.2	3.2	2.2	....	Wheat, oats, corn, cracked corn, barley, sunflower, oil cake meal, wheat screenings with weed seeds, grit.
	F. J. Stuart, Pontiac, Mich.								
B 2995	Stuart's Chicken Feed	Pontiac	G.*	......	9.8	3.4	2.9	....	
			F.*	14.0	8.9	3.1	3.1	4 25	Corn, wheat, oats, barley, buckwheat, sunflower, charcoal.
	Valley City Milling Co., Grand Rapids, Mich.								
B 3091	Rowena Egg Mash	Grand Rapids	G.*	......	15.0	3.0	10.0	....	
			F.*	12.0	16.3	4.0	8.9	3 45	Alfalfa meal, wheat bran, middlings, corn feed meal, corn, bran, meat scraps, linseed meal, salt.

B 2517	Rowena Scratch Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	12.8	10.4	2.6	3.9	4 20	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower.
B 3089	Rowena Scratch Feed	Grand Rapids		12.8	11.3	3.6	4.2	4 00	Same as B 2517.
B 3090	Rowena Scratch Feed	Grand Rapids		12.3	9.6	3.2	3.7	3 80	Same as B 2517 with grit.
		Average		12.6	10.4	3.1	3.9	......	
	Watson Higgins Co., Grand Rapids, Mich.								
B 2576	Perfection Chick Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	11.8	16.5	2.4	1.9	100 00	Cracked corn, kaffir, wheat, oats, millet, grit, weed seeds.
B 2511	Perfection Scratch Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	11.6	11.0	3.7	4.4	78 00	Cracked corn, wheat, oats, barley, grit, weed seeds.
B 3049	Perfection Scratch Feed	Comstock Park		13.1	10.9	2.4	4.4	78 00	Same as B 2511 with buckwheat and kaffir.
B 3092	Perfection Scratch Feed	Grand Rapids		11.7	10.4	3.0	4.5	......	Same as B 3049 without grit.
B 3132	Perfection Scratch Feed	Sparta		11.9	9.8	2.5	4.3	85 00	Same as B 3049.
B 3144	Perfection Scratch Feed	Grand Rapids		8.7	6.6	1.8	6.6	......	Same as B 3049.
		Average		11.4	9.7	2.7	4.8	......	
	E. L. Wellman, Grand Rapids, Mich.								
B 2955	Wellman's Qualiteed Poultry Feed	Lansing	G.*	......	10.0	2.5	5.0	......	
			F.*	12.8	11.6	3.6	4.0	$4 00	Cracked corn, kaffir, wheat, oats, barley, wild buckwheat, wheat screenings.
B 2965	Wellman's Qualiteed Poultry Feed	Lapeer		12.0	11.9	3.5	4.4	4 00	Same as B 2955.
B 3030	Wellman's Qualiteed Poultry Feed	Cadillac		12.2	11.3	3.9	4.3	4 25	Same as B 2955.
B 3060	Wellman's Qualiteed Poultry Feed	Grand Rapids		12.4	11.3	4.0	4.3	74 00	Same as B 2955 with weed seeds, no screenings.
B 3242	Wellman's Qualiteed Poultry Feed	Mason		13.2	10.4	2.9	3.1	4 00	Same as B 3060.
B 3268	Wellman's Qualiteed Poultry Feed	Allegan		12.0	11.1	3.8	5.5	4 00	Same as B 3060.
B 3307	Wellman's Qualiteed Poultry Feed	Leslie		12.9	10.9	2.8	4.1	4 00	Same as B 3060 without weed seeds.
B 3061	Wellman's Qualiteed Poultry Feed	Grand Rapids		11.8	10.7	3.8	3.9	71 00	Same as B 3060 with grit.
		Average		12.4	11.2	3.5	4.2	......	
B 3161	Wellman's Qualiteed Chick Feed	Benton Harbor	G.*	......	10.0	2.5	5.0	......	
			F.*	11.0	10.1	4.2	2.9	$4 10	Cracked wheat, cracked corn, kaffir, flaxseed, milo, oat meal, wild buckwheat, weed seeds, charcoal, grit.
	Western Grain Products Co., Hammond, Ind.								
B 2878	Calumet Scratch Feed	Grand Ledge	G.*	......	10.0	2.5	5.0	......	
			F.*	10.9	11.5	2.8	5.0	4 25	Cracked corn, kaffir, wheat, oats, barley, buckwheat, sunflower, screenings, grit.
B 2482	Hammond Scratch Feed	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	11.7	11.5	2.9	3.3	77 00	Cracked corn, kaffir, wheat, oats, barey, buckwheat, grit, weed seeds.
	C. C. Wright, Owosso, Mich.								
B 2919	Wright's Mixture	Owosso	G.*	......	10.0	2.5	5.0	......	
			F.*	13.6	10.8	3.4	3.4	4 30	Cracked corn, wheat, oats, barley, buckwheat, sunflower weed seeds.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	Wykes & Co., Grand Rapids, Mich.								
B 2491	*Y X Poultry Feed*	Grand Rapids	G.*	......	10.0	2.5	5.0	......	
			F.*	*11.2*	*11.4*	3.4	4.1	$73 00	Cracked corn, kaffir, wheat, oats, barley, sunflower, wild buckwheat, weed seeds, grit.
	CORN AND OAT FEEDS.								
	J. J. Badenoch Co., Chicago, Ill.								
B 2700	C & O Chop	*Ann Arbor*	G.*	......	9.0	3.0	12.0	......	
			F.*	8.6	9.4	4.0	12.0	3 00	Corn feed meal, oat shorts, oat *middlings, oat hulls*, hominy feed salt.
	Beck Cereal Co., Detroit, Mich.								
B 1881	Royal Chop Feed	Detroit	G.*	......	8.3	5.1	5.8	......	
			F.*	10.8	10.0	5.9	7.9	3 10	Oat middlings, oat hulls, ground corn.
B 1956	Royal Chop Feed	Detroit		9.3	10.4	6.4	7.5	*3 05*	*Oat middlings*, oat hulls, ground corn.
		Average		*10.2*	*10.2*	6.2	7.7	......	
	Commercial Milling Co., Detroit, Mich.								
B 1901	Henkel's Chop Feed	Detroit	G.*	......	8.5	3.5	10.0	......	
			F.*	9.8	8.9	3.1	9.5	......	Oats, oat hulls, corn feed meal, wheat screenings, wheat middlings, rye, rye middlings, kaffir.
B 3042	Henkel's Chop Feed	*Howard City*		11.9	8.6	4.6	8.3	$80 00	Corn feed meal, oat hulls, oats, oat and rye middlings, grain screenings.
B 3212	Henkel's Chop Feed	Webberville		12.4	9.8	5.6	6.2	3 50	Oat shorts, oat hulls, oats, rye middlings, corn meal.
		Average		11.3	9.1	4.4	8.0	......	
	H. M. Hobart & Son, Detroit, Mich.								
B 1965	P & H Chop Feed	Detroit	G.*	......	*9.0*	*3.1*	5.2	......	
			F*	9.7	10.6	4.0	6.1	$59 00	Oat middlings, oat, hulls corn feed meal.
	Lichtenberg & Son, Detroit, Mich.								
B 1949	Lichtenberg's Chop Feed	Detroit	G.*	......	8.5	4.0	8.0	......	
			F*	9.5	10.5	5.5	6.6	65 00	Hominy feed, oat hulls, corn feed meal, corn bran
	Scheuren & Mok, Detroit Mich.								
B 3236	Chop Feed	Detroit	G.*	......	7.6	2.2	7.2	......	
			F.*	13.3	8.3	3.3	6.1	*3 10*	*Corn meal, corn bran*, whole and ground oats with mill run ground screenings.

	David Stott Milling Co., Detroit, Mich.								
B 1964	Winter Chop Feed	Detroit	G.*	......	9.5	5.0	8.5	....	
			F.*	9.1	9.6	5.1	7.7	....	Oat shorts, oat hulls, corn feed meal.
	Thoman Milling Co., Lansing, Mich.								
			G.*	......	9.5	2.5	5.0	....	
B 2956	Ground Feed	*Lansing*	F.*	12.6	11.3	4.8	4.3	3 30	Wheat, oats, corn, buckwheat, barley, screenings.

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	WHEAT BRAN.							
	Bernet Craft & Kaufman Milling Co., St. Louis, Mo.							
B 2906	Wheat Bran with ground screenings not exceeding mill run	Pontiac	G.*	......	14.5	4.0	9.5	....
			F.*	11.0	15.6	4.2	9.1	2 25
	J. P. Burroughs & Son, Flint, Mich.							
B 2927	Choice Winter Wheat Bran ground screenings not exceeding mill run	Perry	G.*	......	12.5	3.0	10.5	....
			F.*	10.3	14.4	4.0	10.5	2 25
B 2975	Choice Winter Wheat Bran ground screenings not exceeding mill run	Clio		11.7	14.6	3.8	9.4	40 00
		Average		11.0	14.5	3.9	10.0	....
B 3028	C. V. Bran with ground screenings not exceeding mill run	Reed City	G.*	......	15.0	4.0	14.6	....
			F.*	11.4	16.3	5.4	9.6	$50 00
	George C. Christian, Minneapolis, Minn.							
B 1889	Jersey Wheat Bran ground screenings not exceeding mill run	Detroit	G.*	......	13.0	4.0	13.0	....
			F.*	11.4	15.1	5.1	10.7	....
	William A. Coombs Milling Co., Coldwater, Mich.							
B 2914	Bran, ground screenings not exceeding mill run	Coldwater	G.*	......	14.0	3.0	8.0	....
			F.*	10.1	14.5	4.3	9.3	....
	Everett-Augenbaugh & Co., Waseca, Minn.							
B 2815	E. A. Co. Wheat Bran ground screenings not exceeding mill run	Vassar	G.*	......	14.0	3.0	12.0	....
			F.*	9.1	16.7	5.3	10.7	40 00
B 2944	E. A. Co. Wheat Bran ground screenings not exceeding mill run	Gladwin		11.6	17.0	4.9	9.4	45 00
		Average		10.4	16.9	5.1	10.2	....
	J. Hale & Sons Ionia, Mich.							
B 2495	Flake Bran ground screenings not exceeding mill run	Grand Rapids	G.*	......	14.0	3.5	7.6	....
			F.*	11.4	14.4	3.8	9.1	$40 00
B 2862	Flake Bran ground screenings not exceeding mill run	Jackson		10.5	14.4	3.8	8.5	45 00
		Average		10.9	14.4	3.8	8.8	....
	W. J. Jennison Co., Minneapolis, Minn.							
B 2855	Wheat Bran ground screenings not exceeding mill run	Harbor Beach	G.*	......	14.0	4.0	12.0	....
			F.*	9.3	15.0	5.3	9.8	$46 00
	The Lindsborg Milling & Elevator Co., Lindsborg, Kan.							
B 3184	Wheat Bran and screenings	Muskegon Hts.	G.*	......	14.5	3.5	11.0	....
			F.*	11.7	15.9	4.1	10.0	50 00
	National Feed Co., St. Louis, Mo.							
B 2600	Wheat Bran with screenings not exceeding mill run	Holland	G.*	......	14.5	4.0	10.0	....
			F.*	9.7	14.9	4.1	10.3	45 00
	Pillsbury Flour Mills Co., Minneapolis, Minn.							
B 2694	Durum Wheat Bran with ground screenings not exceeding mill run	St. Joseph	G.*	......	11.0	4.0	14.0	....
			F.*	9.2	13.9	5.6	14.8	....
B 1879	Pillsbury's Wheat Bran ground screenings not exceeding mill run	Detroit	G.*	......	13.0	4.0	13.0	....
			F.*	9.4	13.9	5.8	14.9	36 00
B 2547	Pillsbury's Wheat Bran ground screenings not exceeding mill run	Nunica		11.0	15.4	5.5	11.1	42 00
		Average		10.2	14.7	5.7	13.0	....

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ANALYSES OF FEEDING STUFFS FOR 1917-1918—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	The Red Star Milling Co., Wichita, Kan.						
		G.*	......	14.5	3.5	10.0	....
B 3118	Wheat Bran and screenings	Petoskey ..... F.*	9.7	17.9	4.4	10.8	$45 00
B 3129	Wheat Bran and screenings	Jamestown	10.6	17.1	4.1	10.0	48 00
		Average	10.2	17.5	4.3	10.4	....
	Shane Bros. & Wilson Co., Minneapolis, Minn.						
		G.*	......	14.1	5.5	11.5	....
B 2925	Clover Leaf Wheat Bran ground screenings not exceeding mill run	Owosso ..... F.*	11.4	14.2	5.2	11.2	$45 00
	Sheffield King Milling Co., Minneapolis, Minn.						
		G.*	......	13.5	3.5	12.8	....
B 3317	Fancy Brodflake Wheat Bran and ground screenings	Detroit ..... F.*	10.4	14.6	5.4	11.3	41 00
	Star & Crescent Milling Co., Chicago, Ill.						
		G.*	......	15.0	4.0	10.0	....
B 2525	Crescent Winter Wheat Bran with ground screenings not exceeding mill run	Grandville ..... F.*	10.7	14.2	4.0	9.2	38 00
B 2527	Crescent Winter Wheat Bran with ground screenings not exceeding mill run	Zeeland	13.3	15.0	3.9	8.9	40 00
B 2608	Crescent Winter Wheat Bran with ground screenings not exceeding mill run	Holland	10.3	14.9	4.6	9.9	46 00
B 2643	Crescent Winter Wheat Bran with ground screenings not exceeding mill run	Allegan	10.5	15.8	5.1	10.2	38 00
B 2689	Crescent Winter Wheat Bran with ground screenings not exceeding mill run	Benton Harbor	10.2	15.6	4.4	10.7	42 00
B 2933	Crescent Winter Wheat Bran with ground screenings not exceeding mill run	Millington	10.2	15.3	3.8	9.0	45 00
		Average	10.9	15.1	4.3	9.7	....
	F. W. Stock & Son, Hillsdale, Mich.						
		G.*	......	14.0	3.0	10.0	....
B 3265	Bran made from pure wheat with mill run screenings	Schoolcraft ..... F.*	10.7	14.8	3.9	10.0	$40 00
	David Stott Milling Co., Detroit, Mich.						
		G.*	......	13.5	4.0	11.5	
B 1963	Spring Wheat Bran and wheat screenings	Detroit ..... F.*	9.5	15.4	4.2	8.6	....
	Valley City Milling Co., Grand Rapids, Mich.						
		G.*	......	14.1	4.6	10.1	....
B 2519	Farmer s Favorite Wheat Bran with ground screenings not exceeding mill run	Grand Rapids ..... F.*	11.4	14.8	4.0	9.6	42 00
B 2875	Farmer s Favorite Wheat Bran with ground screenings not exceeding mill run	Williamston	10.2	14.3	4.3	10.6	48 00
B 3004	Farmer s Favorite Wheat Bran with ground screenings not exceeding mill run	Mulliken	9.8	14.4	4.3	10.4	45 00
B 3041	Farmer s Favorite Wheat Bran with ground screenings not exceeding mill run	Howard City	11.0	14.5	4.3	9.2	50 00
		Average	10.6	14.5	4.2	10.0	....
		G.*	......	14.1	4.6	10.1	....
B 2538	Rowena Wheat Bran with ground screenings not exceeding mill run	Zeeland ..... F.*	10.5	15.2	4.0	9.6	$40 00
	Voigt Milling Co., Grand Rapids, Mich.						
		G.*	......	14.0	4.0	11.0	....
B 2470	Crescent Bran with ground screenings not exceeding mill run	Coopersville ..... F.*	11.2	14.7	3.9	9.5	38 00
B 2679	Crescent Bran with ground screenings not exceeding mill run	Bangor	11.3	16.1	4.5	8.0	48 00
B 3038	Crescent Bran with ground screenings not exceeding mill run	Big Rapids	11.2	14.8	4.3	8.9	40 00
B 3046	Crescent Bran with ground screenings not exceeding mill run	Cedar Springs	11.8	14.6	4.1	8.7	40 00
B 3110	Crescent Bran with ground screenings not exceeding mill run	Rockford	9.8	15.2	4.3	10.6	42 00
		Average	11.1	15.1	4.2	9.1	....

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ANALYSES OF FEEDING STUFFS FOR 1917-1918—Continued.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Wagner White Co., Inc., Jackson, Mich.							
B 2631	*Bran with ground screenings not exceeding mill run*	Kalamazoo	G.*	......	14.0	4.0	11.0	....
			F.*	9.8	15.9	4.6	11.1	$34 00
B 2637	Bran with ground screenings not exceeding mill run	Kalamazoo		10.0	14.2	4.0	10.6	48 00
B 2638	Bran with *ground screenings not exceeding mill run*	*Kalamazoo*		*10.1*	*17.6*	*4.0*	*9.0*	*48 00*
B 2691	Bran with ground screenings not exceeding mill run	Benton Harbor		10.3	17.8	4.3	8.2	42 00
B 2732	Bran with ground screenings not exceeding mill run	Mason		10.4	17.4	4.0	9.0	45 00
B 3104	Bran with ground screenings not exceeding mill run	Coopersville		10.1	15.2	4.2	10.4	42 00
		Average		10.1	16.4	4.2	9.7	....
	Washburn Crosby Co., Minneapolis, Minn.							
B 1959	Wheat bran with ground screenings not exceeding mill run	Detroit	G.*	......	13.0	4.0	13.0	....
			F.*	9.1	14.5	5.2	10.8	36 00
B 2611	Wheat *bran with ground screenings not exceeding* mill run	Holland		10.2	14.1	5.2	11.3	45 00
B 2743	Wheat bran with ground screenings not exceeding *mill run*	*Leslie*		*10.4*	*14.8*	*4.3*	*10.1*	*45 00*
B 2824	Wheat bran with ground screenings not exceeding mill run	Mayville		9.6	15.1	5.1	10.7	45 00
		Average		9.8	14.6	5.0	10.7	....
	Western Flour Mills, Davenport, Iowa.							
B 2832	Black Hawk Wheat Bran ground screenings not exceeding mill run	Bad Axe	G.*	......	13.3	3.0	11.3	....
			F.*	10.4	16.4	5.4	10.3	$42 00
	WHEAT MIDDLINGS.							
	Baldwin Flour Mills, Minneapolis, Minn.							
B 3031	Wheat Shorts with ground screenings not exceed- mill run	Cadillac	G.*	......	15.5	5.0	10.0	....
			F.*	10.5	16.5	5.4	8.4	56 00
	Bay State Milling Co., Winona, Minn.							
B 2724	Winona Wheat Middlings with ground screenings not exceeding mill run	North Adams	G.*	......	16.0	5.0	8.0	....
			F.*	10.8	17.4	5.7	7.3	46 00
	Bernet Craft & Kaufman Milling Co., St. Louis Mo.							
B 2997	Wheat Middlings ground screenings not exceeding *mill run*	*Pontiac*	G.*	......	*17.2*	4.9	*6.0*	....
			F.*	11.7	16.6	4.4	5.0	58 00
	Big Diamond Mills Co., Minneapolis, Minn.							
B 2734	Big Diamond Wheat Standard Middlings ground screenings not exceeding mill run	Mason	G.*	......	14.6	4.2	9.3	....
			F.*	10.7	17.3	4.9	7.2	40 00
	George C. Christian, Minneapolis, Minn.							
B 2911	Berkshire Wheat Flour Middlings ground screenings not exceeding mill run	Sturgis	G.*	......	15.0	4.0	8.0	....
			F.*	9.5	16.9	6.0	5.8	52 00
B 1977	Poland Wheat Standard Middlings ground screenings not exceeding mill run	Clinton	G.*	......	14.0	4.0	11.0	....
			F.*	*10.6*	*17.2*	*5.4*	7.1	50 00
	Commercial Milling Co., Detroit, Mich.							
B 1896	Standard Wheat Middlings ground screenings not exceeding mill run	Detroit	G.*	......	13.5	4.5	10.0	....
			F.*	10.3	18.6	5.6	6.5	42 00
B 1903	Standard Wheat Middlings ground screenings not exceeding mill run	Detroit		10.3	17.4	5.6	6.7	....
B 2626	Standard Wheat Middlings ground screenings not exceeding mill run	Kalamazoo		10.7	17.4	6.0	7.2	52 00
B 2837	Standard Wheat Middlings ground screenings not exceeding mill run	Port Huron		10.8	17.4	5.8	7.3	53 00
B 3224	*Standard Wheat Middlings ground screenings not* exceeding mill run	Detroit		11.7	14.8	5.0	8.2	2 25
		Average		10.7	17.1	5.6	7.2	....

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude	Crude fat.	Crude fiber.	Price per ton or cwt.
	The Des Peres Milling Co., St. Louis, Mo.							
B 3293	Wheat Shorts with ground wheat screenings not exceeding mill run	Otsego	G.*	......	15.0	3.5	12.0	....
			F.*	11.1	16.3	5.1	7.5	$2 40
	Eagle Roller Mill Co., New Ulm, Minn.							
B 2836	Wheat Middlings ground screenings not exceeding mill run	Port Huron	G.*	......	15.0	4.0	11.0	....
			F.*	10.4	16.3	5.0	10.0	53 00
B 2951	Wheat Middlings ground screenings not exceeding mill run	Midland		11.0	16.2	5.1	9.2	2 60
B 3023	Wheat Middlings ground screenings not exceeding *mill run*	Clare		10.9	18.1	5.6	8.5	55 00
B 3036	Wheat Middlings ground screenings not exceeding mill run	Big Rapids		11.3	15.7	4.9	9.5	47 00
		Average		10.9	16.6	5.2	8.8	....
	Everett Augenbaugh Co., Waseco, Minn.							
B 2572	E. A. Co. Wheat Middlings with ground screenings not exceeding mill run	N. Muskegon	G.*	......	15.0	3.0	10.0	....
			F.*	10.8	18.3	5.6	7.5	$50 00
	Hubbard Milling Co., Mankato, Minn.							
B 2723	*Standard Fine Middlings ground screenings not* exceeding mill run	North Adams	G.*	......	18.0	5.0	11.5	....
			F.*	10.8	17.4	6.2	9.0	46 00
	Kemper Mill & Elevator Co., Kansas City, Mo.							
B 2657	Wheat Middlings with ground screenings not exceeding mill run	Battle Creek	G.*	......	16.0	4.0	8.0	....
			F.*	10.6	16.8	4.5	7.2	56 00
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
B 1979	Badger Fancy Middlings	Clinton	G.*	......	12.0	4.5	7.0	....
			F.*	10.5	13.1	7.7	4.7	60 00
B 2697	Badger Fancy Middlings	Greenville		10.2	13.0	7.7	3.9	56 00
B 2702	Badger Fancy Middlings	Adrian		10.3	13.1	6.3	2.9	2 75
		Average		10.3	13.1	7.2	3.8	....
	Lyon & Greenleaf Co., Wauseon, Ohio.							
B 1983	*Waseo Middlings ground screenings not exceeding* mill run	Blissfield	G.*	......	17.0	4.0	6.0	....
			F.*	10.7	15.7	4.5	5.8	$52 00
	Montana Flour Mills Co., Lewistown, Mont.							
B 2000	Montco Wheat Middlings with ground screenings not exceeding mill run	Adrian	G.*	......	15.7	4.7	9.6	....
			F.*	10.8	19.1	5.2	7.4	2 25
	National Feed Co., St. Louis, Mo.							
B 3093	Wheat Middlings with ground screenings not exceeding *mill run*	Muskegon	G.*	......	16.0	4.0	9.0	....
			F.*	10.6	17.6	5.2	7.5	62 00
B 3124	Wheat Middlings with ground screenings not exceeding mill run	Jamestown		10.8	16.9	5.6	7.2	58 00
		Average		10.7	17.5	5.4	7.4	....
	The Northwestern Consolidated Milling Co. Minneapolis, Minn.							
B 2942	Wheat Standard Middlings ground screenings not exceeding mill run	Gladwin	G.*	......	15.0	4.5	11.0	....
			F.*	10.6	16.7	5.9	9.6	$50 00
	Pillsbury Flour Mills Minneapolis Minn.							
B 2629	Standard Middlings with ground screenings not exceeding mill run	Kalamasoo	G.*	......	14.0	4.0	11.0	....
			F.*	10.7	16.9	5.5	9.1	52 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Schultz Banjau & Co., Beardstown, Ill.							
B 3152	Sunbeam middlings with mill run screenings	Coopersville	G.*	......	15.0	3.5	10.0	....
			F.*	11.7	15.6	4.7	7.2	$53 00
	Shane Bros. & Wilson Co., Minneapolis, Minn.							
B 2901	Snowball Wheat White Middlings ground screenings not exceeding mill run	Albion	G.*	......	15.0	4.5	7.0	....
			F.*	10.1	16.3	6.3	11.0	2 75
B 2920	Snowball Wheat White Middlings ground screenings not exceeding mill run	Owosso		10.9	17.2	5.8	7.1	2 85
		Average		10.5	16.7	6.1	9.2	....
B 2895	Wheat Standard Middlings with ground screenings not exceeding mill run	Milan	G.*					
			F.*	......	15.3	6.4	10.5	....
B 2922	Wheat Standard Middlings with ground screenings	Owosso		10.4	16.1	5.8	10.4	$45 00
				11.0	14.3	5.5	11.3	2 50
		Average		10.7	15.2	5.7	10.9	....
	Stanard Tilton Milling Co., St. Louis, Mo.							
B 2599	Wheat Middlings with ground screenings not exceeding mill run	Holland	G.*	......	15.0	4.0	6.0	....
			F.*	10.4	17.2	4.6	5.5	$56 00
	Star & Crescent Milling Co., Chicago, Ill.							
B 2756	Star Wheat Middlings ground screenings not exceeding mill run	St. Johns	G.*	......	15.0	4.0	8.0	....
			F.*	10.9	17.7	5.2	7.5	2 50
B 2932	Star Wheat *Middlings ground screenings not exceeding* mill run	Millington		10.5	17.0	4.2	6.7	2 50
		Average		10.7	17.4	4.7	7.1	....
	Valley City Milling Co., Grand Rapids, Mich.							
B 2464	Farmer's Favorite Wheat Middlings with ground screenings not exceeding mill run	Coopersville	G.*	......	13.0	4.8	7.5	....
			F.*	11.7	15.4	4.4	7.6	$50 00
B 2518	Farmer's Favorite Wheat Middlings with ground screenings not exceeding mill run	Grand Rapids		11.2	15.9	4.4	7.1	53 00
		Average		11.5	15.7	4.4	7.4	....
B 2539	Rowena Wheat Middlings with ground screenings *not exceeding mill run*	*Zeeland*	G.*	......	13.0	5.2	7.5	....
			F.*	11.1	18.4	4.8	6.7	$56 00
B 2543	Rowena Wheat Middling swith ground screenings not exceeding mill run	Holland		11.4	16.0	4.8	7.3	54 00
B 2579	Rowena Wheat Middlings with ground screenings not exceeding mill run	Sparta		10.7	15.8	4.9	5.9	57 00
B 2748	Rowena Wheat Middlings with ground screenings not exceeding mill run	St. Johns		10.8	15.8	4.8	7.1	2 75
		Average		11.0	16.5	4.8	6.8	....
	Voigt Milling Co., Grand Rapids, Mich.							
B 2613	Voigt Milling Co. Middlings	Moline	C.*	......	14.5	3.5	10.0	....
			F.*	11.7	15.7	4.5	6.3	$47 00
	Washburn Crosby Co., Minneapolis, Minn.							
B 1954	Standard Middlings ground screenings not exceeding mill run	Detroit	G.*	......	14.0	4.0	11.0	....
			F.*	9.0	17.3	5.7	9.1	2 25
B 2487	Standard Middlings ground screenings not exceeding mill run	Grand Rapids		10.9	16.5	5.0	9.5	48 00
B 2814	Standard Middlings ground screenings not exceeding mill run	Vassar		9.8	17.3	5.5	8.3	3 25
B 2825	Standard *Middlings ground screenings not exceeding* mill run	Mayville		9.4	16.3	5.5	9.4	2 65
		Average		9.8	16.9	5.4	9.1	....
B 2826	Wheat Flour Middlings grounds creenings not exceeding mill run	Mayville	G.*	......	15.0	4.0	8.0	....
			F.*	9.9	18.7	6.0	6.2	$2 80

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONTINUED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	WHEAT MIXED FEEDS.							
	Huron Milling Co., Harbor Beach, Mich.							
B 2839	Jenks Wheat Mixed Feed with ground screenings *not exceeding mill run*	*Port Huron*	G.*	......	13.0	3.5	11.5	......
			F.*	*10.7*	15.0	4.4	8.7	*$48 00*
B 2856	Jenks Wheat Mixed Feed with ground screenings not exceeding mill run	Harbor Beach		10.0	14.4	3.9	8.4	......
		Average		10.4	14.7	4.2	8.6	......
	Portland Milling Co., Portland, Mich.							
B 2876	Champion Mixed Feed with ground screenings not exceeding *mill run*	*Williamston*	G.*	......	13.5	3.5	8.4	......
			F.*	*10.7*	*15.2*	*4.3*	*7.7*	......
	F. W. Stock & Son, Hillsdale, Mich.							
B 3275	Monarch Feed	Hillsdale	G.*	......	10.0	4.0	10.0	......
			F.*	*10.3*	*15.6*	*4.8*	*9.9*	*$2 05*
	Washburn Crosby Co., Minneapolis, Minn.							
B 1960	Wheat Mixed Feed ground screenings not exceeding *mill run*	*Detroit*	G.*	......	14.0	4.0	10.0	......
			F.*	*9.5*	*17.3*	*5.4*	*6.8*	*2 10*
	WHEAT AND RYE MIXED FEEDS.							
	Commercial Milling Co., Detroit, Mich.							
B 1890	Henkel's Fine White Feed	Detroit	G.*	......	14.0	5.0	8.5	......
			F.*	11.4	15.4	4.8	9.0	2 50
B 1904	Henkel's Fine White Feed	Detroit		9.9	15.9	4.6	7.9	......
B 1992	Henkel's Fine White Feed	Morenci		10.5	14.8	4.6	6.9	58 00
B 3225	Henkel's Fine White Feed	Detroit		11.4	13.9	4.9	**13.1**	2 50
		Average		10.8	15.0	4.7	9.2	......
	B. A. Eckhart Milling Co., Chicago, Ill.							
B 2604	Wheat & Rye Flour Middlings	Holland	G.*	......	15.0	4.0	7.0	......
			F.*	10.6	17.6	4.8	4.8	$48 00
	CEREAL FOOD BY-PRODUCTS.							
	J. E. Bartlett Co., Jackson, Mich.							
B 2655	Toasted Milk Nuts	Jackson	G.*	......	14.4	1.5	6.5	......
			F.*	10.9	14.5	1.4	7.7	......
B 2722	Toasted Milk Nuts	North Adams		9.8	15.9	1.5	7.4	......
B 2865	Toasted Milk Nuts	Jackson		10.0	15.3	1.4	7.6	1 65
		Average		10.2	15.2	1.4	7.6	......
	Kellogg Toasted Corn Flake Co., Battle Creek, Mich.							
B 2652	Broken Wheat Biscuit	Battle Creek	G.*	......	10.1	1.0	2.6	......
			F.*	6.5	12.6	1.9	4.8	$45 00
B 2653	Dried Corn Flake Feed	Battle Creek	G.*	......	6.9	2.1	0.4	......
			F.*	7.3	8.5	1.6	0.8	45 00
B 2717	*Dried Corn Flake Feed*	*Hudson*		*7.6*	*9.1*	*2.4*	*0.5*	*55 00*
		Average		7.5	8.8	2.0	0.7	......
	Postum Cereal Co., Battle Creek, Mich.							
B 2669	Cereal	Battle Creek	G.*	......	12.0	1.7	18.0	......
			F.*	4.5	13.0	2.6	13.4	$23 00
B 2647	Cooked Corn Grits	Battle Creek	G.*	......	6.6	0.2	2.0	......
			F.*	13.9	8.3	0.6	0.4	46 00
B 2651	CXX Feed	Battle Creek	G.*	......	15.0	2.0	26.0	......
			F.*	6.9	18.6	4.3	20.9	23 00
B 2714	CXX Feed	Hudson		7.6	18.3	4.2	20.1	1 50
		Average		7.3	18.5	4.3	20.5	......

***Abbreviations for Guaranteed and Found.**

ANALYSES OF FEEDING STUFFS FOR 1917-1918—CONCLUDED.

Laboratory number.	Manufacturer and Trade Name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Postum Cereal Co., Battle Creek, Mich.—Con.							
B 2646	Flaked Corn Feed	Battle Creek	G.*	......	8.0	1.0	5.0	......
			F.*	5.8	9.3	1.4	0.8	$52 00
B 2650	Flaked Corn Offal	Battle Creek	G.*	......	5.0	0.5	2.0	......
			F.*	12.3	8.6	1.5	0.8	50 00
B 2668	G. N. Feed	Battle Creek	G.*	......	9.0	0.5	2.5	......
			F.*	6.7	11.6	1.4	1.5	52 00
	BARLEY FEED.							
	J. E. Bartlett Co., Jackson, Mich.							
B 3139	Barley Feed with ground screenings not exceeding mill run.	N. Muskegon	G.*	......	8.5	2.8	25.3	......
			F.*	9.7	8.1	2.8	24.1	54 00
	Postum Cereal Co., Battle Creek, Mich.							
B 2648	Barley Bran (Hulls)	Battle Creek	G.*	......	8.0	1.3	30.0	......
			F.*	7.0	9.2	2.3	19.1	25 00
B 3000	Barley Bran (Hulls)	Pontiac		10.3	12.1	2.3	13.4	20 00
		Average		*8.7*	*10.7*	*2.3*	*16.3*	......
	Washburn Crosby Milling Co., Minneapolis, Minn.							
B 3123	Barley Screenings	Jamestown	G.*	......	6.0	1.0	25.0	......
			F.*	8.8	8.7	2.7	22.1	$38 00
B 3261	Barley Screenings	Jackson		9.1	7.8	2.5	22.4	2 60
		Average		9.0	8.3	2.6	22.3	......
	RYE FEED.							
	(Rye Bran & Rye Middlings with Ground Screenings.)							
	Bay State Milling Co., Winona, Minn.							
B 1990	Rye Middlings	Morenci	G.*	......	16.0	3.4	6.0	......
			F.*	9.2	15.9	3.5	6.0	47 00
	Hannah & Lay Co., Traverse City, Mich.							
B 3115	Rye Feed	Traverse City	G.*	......	14.1	2.7	4.5	......
			F.*	12.9	14.1	2.7	4.5	50 00
	Valley City Milling Co., Grand Rapids, Mich.							
B 3073	Rowena Rye Feed	Grand Rapids	G.*	......	16.0	2.8	6.3	......
			F.*	11.4	16.1	2.9	4.7	43 00
B 3082	Rowena Rye Feed	Grand Rapids		11.7	16.1	3.1	4.8	40 00
		Average		*11.6*	*16.1*	*3.0*	*4.8*	......
	Voigt Milling Co., Grand Rapids, Mich.							
B 3145	Voigts Rye Feed	Hudsonville	G.*	......	15.0	3.0	6.0	......
			F.*	11.7	15.4	3.4	4.6	$50 00
	MISCELLANEOUS FEEDS.							
	Armour Grain Co., Chicago, Ill.							
B 3166	Oat Hulls	South Haven	G.*	......	5.0	2.0	30.0	......
			F.*	8.3	5.4	1.7	15.1	35 00
	Michigan Cereal Co., Port Huron, Mich.							
B 2835	Pea Bran	Port Huron	G.*	......	14.0	1.0	35.0	......
			F.*	9.1	16.1	1.4	29.5	47 00
	J. E. Bartlett Co., Jackson, Mich.							
B 3263	Velvet Bean Meal	Jackson	G.*	......	18.0	4.5	12.0	......
			F.*	10.9	16.8	4.0	14.3	47 00

***Abbreviations for Guaranteed and Found.**

ANALYSES OF FEEDS REQUIRING NO LICENSE.

Laboratory number.	Manufacturer and Trade Name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Alma Roller Mills, Alma, Mich.						
B 3012	Buckwheat Bran	Alma G.*	......	......	......	......	......
		F.*	10.2	6.1	1.1	36.1	$41 00
	Harris Milling Co., Mt. Pleasant, Mich.						
B 3019	Middlings	Mt. Pleasant G.*	......	......	......	......	......
		F.*	11.0	15.3	4.4	4.8	38 00
	Russell-Miller Milling Co., Minneapolis, Minn.						
B 2921	Bran made from wheat only	Owosso G.*	......	13.0	4.0	11.0	......
		F.*	10.7	16.9	5.6	10.1	2 3
	Larrowe Milling Co., Detroit, Mich.						
B 2721	Dried Beet Pulp	North Adams G.*	......	8.0	0.5	20.0	......
		F.*	8.9	8.9	0.9	19.0	40 00
B 2894	Dried Beet Pulp	Saginaw	8.1	8.9	0.9	19.5	42 00
B 2941	Dried Beet Pulp	Gladwin	10.1	8.9	1.0	18.8	2 20
B 2870	Dried Beet Pulp	Jackson	8.4	9.3	0.8	18.9	2 10
		Average	8.9	9.0	0.9	19.1	......
	Saginaw Milling Co., Saginaw, Mich.						
B 2974	Rye Feed	Clio G.*	......	......	......	......	......
		F.*	12.4	16.3	2.8	4.4	$2 75
	David Stott Milling Co., Detroit, Mich.						
B 1962	Stotts Pure Winter Wheat Bran	Detroit G.*	......	14.0	4.5	10.5	......
		F.*	9.5	15.0	3.9	8.3	......
	John A. Vogtmann, Bay City, Mich.						
B 2949	Wheat Middlings	Bay City G.*	......	......	......	......	......
		F.*	11.5	16.4	5.1	6.6	37 00
	Watso-nHiggins Milling Co., Grand Rapids, Mich.						
B 3044	Wheat Bran	Cedar Springs G.*	......	......	......	......	......
		F.*	11.5	13.3	4.4	7.6	......
B 3050	Wheat Bran	Comstock Park	11.5	13.9	3.9	9.6	37 00
		Average	11.5	13.6	4.2	8.6	......
	E. L. Wellman, Grand Rapids, Mich.						
B 3033	Middlings	Cadillac G.*	......	......	......	......	......
		F.*	10.8	18.2	4.8	5.8	$58 00

*Abbreviations for Guaranteed and Found.

ANALYSES OF FEEDS SOLD IN MICHIGAN IN VIOLATION OF THE FEEDING STUFFS LAW REQUEST FOR LICENSE REFUSED BY MANUFACTURERS.

Laboratory number.	Manufacturer and Trade Nane.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	Alabama Velvet Bean Mills, Georgiana, Ala.							
B 2098	Velvet Bean Feed Meal	Pontiac	G.*	......	18.0	4.2	14.0	....
			F.*	11.7	18.2	4.2	12.9	$2 60
	O. H. Bowen, Birmingham, Ala.							
B 3271	Velvet Bean Meal	White Pigeon	G.*	......	18.0	4.5	12.0	....
			F.*	10.8	**16.9**	3.8	**14.3**	48 00
B 3276	Velvet Bean Meal	Clinton		10.9	**15.4**	3.7	**15.6**	52 00
		Average		10.9	**16.2**	3.8	**14.9**	....
	C. L. Campbell & Co., Little Rock, Ark.							
B 3080	Single Hump Camel Brand Cottonseed Meal	Grand Rapids	G.*	......	38.5	6.0	8.0	....
			F.*	9.1	38.8	6.2	**12.0**	$60 00
B 3210	Cottonseed Meal	Washington	G.*	......	......	......	......	....
			F.*	*8.5*	*36.4*	*6.1*	*11.8*	*55 00*
	Commander Mill Co., Minneapolis, Minn.							
B 2860	Commander Wheat Bran ground screenings not exceeding mill run.	Jackson	G.*	......	14.0	4.0	11.0	....
			F.*	10.1	14.9	5.1	10.7	2 25
	Albert Dickinson Co., Chicago, Ill.							
B 3158	Pine Tree Chick Feed with grit	Portage Centre	G.*	......	10.0	2.5	5.0	....
			F.*	*11.8*	**6.5**	*2.2*	*1.8*	*4 40*
	Hayes Grain & Commission Co., Little Rock, Ark.							
B 2885	Supreme Brand Cottonseed Meal	Plymouth	G.*	......	38.6	6.0	8.0	....
			F.*	8.9	38.7	6.9	**11.4**	2 80
B 2897	Supreme Brand Cottonseed Meal	Albion		9.2	40.0	7.1	**10.5**	55 00
B 2994	Supreme Brand Cottonseed Meal	Milford		8.6	37.6	6.5	**11.4**	60 00
		Average		8.9	38.8	6.8	**11.1**	....

*Abbreviations for Guaranteed and Found.

FERTILIZER ANALYSES

Bulletin No. 283

ANDREW J. PATTEN, C. F. BARNUM, E. F. BERGER,
A. L. LEWIS, M. L. GRETTENBERGER.

The inspection and analysis of commercial fertilizers, sold, offered or exposed for sale in Michigan, is made under authority of an act of the Legislature approved March 10th, 1885, and as amended during the session of 1913. The full text of the law will be sent to any person upon request.

LICENSED BRANDS.

During the year 1918, thirty manufacturers and fertilizer companies licensed 323 brand for sale in the State. Attention is called to the fact that the fertilizer law covers only those materials which are sold, offered or exposed for sale within the State, the retail price of which is $10.00 or more per ton. Manufacturers residing outside the State may ship direct to the consumer without paying the license fee, but the party making the purchase receives no protection under the law. If the sale of fertilizer to be shipped direct to the consumer is made by an agent or representative of the manufacturer while in the State, the act is considered as one of actually offering the material itself for sale, and the fertilizer then becomes subject to the requirements of the law just as surely as though the fertilizer were actually brought into the State and then sold. Consequently, an agent of a fertilizer company is technically violating the law when he solicits or accepts orders for any unlicensed fertilizer, while in the State.

COLLECTION OF SAMPLES

The collection of samples was made during the spring and fall shipping seasons by inspectors appointed by the State Board of Agriculture.

All sections of the State in which fertilizers are used to any extent, were visited and 863 samples were secured from stocks being offered for sale by dealers. For this purpose a specially constructed tube is used which permits of securing a core from the entire length of the bag. An official sample consists of the cores taken from not less than five separate sacks of the same brand. The five or more separate cores are mixed together, placed in a stout sack, tied, sealed and forwarded to the laboratory for analysis.

Much of the fertilizer used in the State is taken directly from the cars by the consumers and it is never possible for the inspectors to secure samples of all the brands registered. It sometimes happens that a manufacturer fails, for some reason or other, to sell any of a particular brand or the sales may be very light and in the latter case it is only by chance that a sample is found.

During the past year, forty-four registered brands were not found in the State. In several cases it is known that no shipments were made.

It was formerly the custom, whenever we failed to find a brand on the market, to analyze the sample forwarded by the manufacturer, as required by law at the time of applying for the license. It has long been known that these samples were generally, if not always, made up in the laboratories of the companies and were not, therefore, representative of the product as put on the market. For this, and other reasons, we have discontinued this practice and in this bulletin the brands not represented by samples are listed in their proper places but are not given a laboratory number and only the guaranteed analysis is shown.

In many cases several samples of the same brand were drawn and analyzed. This, of course, greatly increases the work in the laboratory, but it is the only way by which we can ascertain if the brands are running uniform. If only one sample were analyzed, of it several samples were taken and composited before being analyzed, variations in the composition would not be detected.

ANALYSES OF MISCELLANEOUS SAMPLES

On account of the large amount of work involved in the inspection of fertilizers our laboratory force is kept busy constantly with samples collected by the inspectors. It is, therefore, impossible for us to give attention to miscellaneous fertilizer samples sent to us. Furthermore, unless the samples are taken in the manner previously described they will not truly represent the lot or shipment of which they were a part and the analysis of such a sample would be an injustice either to the manufacturer or purchaser.

In all cases where doubt arises as to the merits of any particular shipment, we suggest that this office be notified and an inspector will be sent to make an investigation and draw an official sample.

RESULTS OF INSPECTION

A study of the tables of analyses shows that, of the 863 samples analyzed representing 279 brands, 187 (21.7%) are below guarantee in one or more constituent. Fifty-four (6.3%) are below guarantee in nitrogen, 5 (0.6%) are below guarantee in total phosphoric acid, 55 (6.4%) are below in available phosphoric acid and 98 (11.4%) in potash. This is a decided improvement over the showing made last year, and represents about the normal or pre-war percentage of deficiencies.

A summary of the results of the inspection is given in the following table:

SUMMARY OF RESULTS OF INSPECTION

Manufacturer.	Number of brands licensed.	Number of samples analyzed.	Number below guarantee in one or more ingredient.	Number equal in value to guarantee.	Number not within 5 per cent of value guaranteed.	Number not within 10 per cent of value guaranteed.	Number 5 per cent or more above value guaranteed.
American Agricultural Chemical Co	80	221	1	221	0	0	217
Armour Fertilizer Works	25	72	27	61	9	5	49
R. Binder Co	1	0	0	0	0	0	0
E. Burton	1	1	1	1	0	0	1
Calumet Fertilizer Co	3	0	0	0	0	0	0
Darling & Company	11	57	27	45	9	5	32
Farmers Fertilizer Co	9	10	5	7	3	0	6
Federal Chemical Co	25	71	26	62	5	1	47
Fertile Chemical Co	2	4	2	1	3	2	1
Gleaner Clearing House Assocition	7	2	0	2	0	0	1
Independent Packers Fertilizer Co	12	30	8	21	4	1	7
International Agricultural Corporation	15	31	4	27	2	0	22
Jarecki Chemical Co	11	49	14	45	3	1	34
Michigan State Grange	7	10	0	10	0	0	9
National Plant Food Co	1	1	0	1	0	0	1
Natural Guano Co	1	0	0	0	0	0	0
Nitrate Agencies Co	1	1	0	1	0	0	0
Nu-Life Fertilizer Co	1	0	0	0	0	0	0
Packers Fertilizer Co	11	22	4	21	0	0	19
Pulverized Manure Co	3	2	0	2	0	0	2
Queen City Fertilizer Co	1	1	0	1	0	0	1
F. S. Royster Guano Co	15	67	13	61	4	2	47
Smith Agricultural Chemical Co	9	37	12	30	5	1	19
J. L. & H. Stadler Rendering & Fertilizer Co	8	17	1	17	0	0	15
N. Swarts	1	1	0	1	0	0	1
Swift & Company	24	85	34	65	13	8	37
United Chemical & Organic Products Co	8	23	5	23	0	0	20
Virginia-Carolina Chemical Co	23	27	3	24	2	1	24
Wolcott Packing Co	2	1	0	1	0	0	1
Wuichet Fertilizer Co	5	20	0	20	0	0	20
	323	863	187	771	62	27	633

A study of the above table brings out the following interesting points:

1. *Eighty-nine (89) per cent of all samples analyzed were equal to the guaranteed value.*
2. Seventy-three (73) per cent of all samples analyzed were 5 per cent or more above the guaranteed value.
3. Seven (7) per cent of all samples analyzed were not within 5 per cent of the guaranteed value.
4. Three (3) per cent of all samples analyzed were not within 10 per cent of the guaranteed value.

SAMPLES REQUIRING SPECIAL MENTION.

Sample A-1788. *Armour's Michigan Special,* manufactured by Armour Fertilizer Works, Chicago, Illinois. This sample was drawn from stock held by L. R. Glassford, Capac. It was found to be below guarantee in potash. Objection was raised on the ground that a mistake in sampling might have been made. Another sample, A-2464, was drawn from the same shipment and the analyses of the two samples are here given for comparison.

Sample No.	Nitrogen	Phosphoric Acid.			Potash.
		Total.	Insoluble.	Available.	
A 1788	0.94%	10.50%	1.16%	9.34%	0.58%
A 2464	0.98%	10.12%	0.97%	9.15%	0.75%

Sample A-2023. *Farmers Favorite,* manufactured by Darling & Company, Chicago, Illinois. The sample was drawn from stock held by Reed & Cheney, Grand Rapids. The analysis was so different from the guarantee it was evident that a mistake had been made by the shipping department of the company. As soon as the matter was called to the attention of Darling & Company, the lot was returned to the factory. The value of the fertilizer delivered was practically equal to that guaranteed.

Sample A-2397, *Staff-O-Life,* manufactured by the Federal Chemical Company, Louisville, Kentucky. The sample was drawn from stock held by the Sioux City Seed Company, Millington. The analysis of the sample corresponds to the "Twenty-four Phosphate" fertilizer manufactured by the same company. When the matter was called to the attention of the company they admitted that a mistake must have been made by the workman in filling the sacks from the wrong pile. The value of the fertilizer delivered was greater than the one ordered.

Sample A-1902. *Penguin Ammoniated Phosphate,* manufactured by F. S. Royster Guano Company, Baltimore, Maryland. The sample was drawn from stock held by F. B. Bachelder, Clarksville. This was sold as a 2-10-0 formula, but our analysis showed it to be a 1-12-0 brand. Objection to the sample was raised by the fertilizer company and a second sample, A-1980, from the same shipment was accordingly taken. The analysis of the second sample agreed closely with the first sample. The F. S. Royster Guano Company accepted the second result as evidence of an error on their part and promptly paid Mr. Bachelder the difference between the 2-10-0 and 1-12-0 brands.

Sample A-2549. *High Grade Acid Phosphate 16%,* manufactured by F. S. Royster Guano Company. Sample was drawn at the request of C. H. Barton, Grand Ledge, who stated that it contained stones and was the cause of breaking several seed drills. Upon investigation it was found that the "stones" were untreated rock phosphate that had spilled over from an overhead carrier in the factory and owing to a breakdown this particular lot of acid phosphate was not screened before being bagged. After making an investigation, F. S. Royster Guano Company paid the damages on the broken drills and also for having the remaining lot of fertilizer screened.

LIME-FERTILE

The material is licensed by the Fertile Chemical Co., Cleveland, Ohio, The only guarantee filed with the application is for 3.00 per cent phosphoric acid.

Three samples were drawn by the inspectors, two of which were found to be more than 0.2 per cent below guarantee. The samples were also found to contain the following percentages of calcium and magnesium carbonates.

	Calcium and Magnesium Carbonates
A 2573	86.48%
A 2585	87.23%
A 2620	87.80%

The analytical results indicate that the material is a mixture of approximately 90 per cent pulverized limestone and 10 per cent ground raw rock phosphate.

It is claimed by the manufacturers that "Lime-Fertile" is inoculated with "all-crop nitrogen-fixing bacteria." All three samples were referred to the Bacteriological Department for examination as to bacterial content and their report follows:

"Ashby's Nitrogen-poor Agar was used for plating the samples of 'Lime-Fertile' with the following results:

A 2585—Contained roughly an average of 510,500 bacteria per gram, only 1000 colonies of which might be designated as the nitrogen-fixing type.

A 2573—Contained an average of 5,000 bacteria per gram, none of which were B. radicicola.

A 2620—Contained roughly an average of 234,700 bacteria per gram, 125,000 colonies of which might be designated as the nitrogen-fixing type.

"Fertile soils contain, instead of a few hundred thousand, many million bacteria per gram, from one to several hundred thousand per gram of which are organisms of the nitrogen-fixing type. Data compiled in our own laboratory show that *poor sandy soils* having from one to five million bacteria per gram contain from 23,000 to 424,000 bacteria per gram of the nitrogen-fixing type.

"This shows that sample A-2620 of 'Lime-Fertile' contained a little over half as many organisms of the nitrogen-fixing type as did the most fertile of the samples of poor sandy soil analyzed, while sample A-2585, although it had a comparatively large bacterial count, contained but very few colonies of the nitrogen-fixing type, while sample A-2573 contained none at all.

"Thus it is evident that none of these samples would add any considerable numbers of bacteria of any type, especially nitrogen-fixing bacteria, to soil."

Several misleading statements were noted on the packages of "Lime-Fertile" and also in an advertising circular put out by the company. One of the most glaring statements is the following, taken from page 4 of the circular: "What it does. Lime-Fertile does the work of a complete fertilizer plus liming. Two hundred pounds of Lime-Fertile can be used instead of two hundred pounds of ordinary commercial fertilizer plus one ton of lime or two tons of ground limestone."

The only comment that is necessary is a comparison of the amounts of plant-food and lime furnished in the two cases.

200 lbs. Lime-Fertile contains				200 lbs. Commercial Fertilizer and 2 tons Limestone contain			
Nitrogen	Unavailable P_2O_5	Potash	Lime Carbonates	Nitrogen	Available P_2O_5	Potash	Lime* Carbonates
0	6 lbs.	0	180 lbs.	2 lbs.	16 lbs.	4 lbs.	3,720 lbs.

*Assuming the limestone to contain 93 per cent calcium and magnesium carbonates.

Many other misleading statements were brought to the attention of the manufacturers.

Court Case

During the past year the first court case under the fertilizer law was successfully terminated. In the early part of May this office was notified of a product purporting to be a commercial fertilizer which was being sold throughout Lapeer county. An investigation was immediately started which disclosed that one, Richard Stafford of North Branch, Michigan, purchased a carload of pulverized limestone from the Solvay Process Co. of Detroit. This was packed in 100 pound paper sacks and was plainly marked as pulverized limestone. The cost of the limestone was $4.17 per ton laid down at North Branch. Mr. Stafford called it a "government fertilizer" and sold it for $12.00 per ton, claiming it to be a lime and phosphate mixture.

An inspector from this office accompanied by Mr. L. T. Bishop, county agricultural agent of Lapeer county, called upon several men who had purchased portions of the shipment and drew an official sample.

After a chemical analysis proved it to be nothing but pulverized limestone the evidence was laid before the prosecuting attorney of Lapeer county. On June 21, 1918, a hearing was granted Mr. Stafford in the Justice court when he plead guilty to the charge. He was bound over to the Circuit court for sentence and on June 27 was fined $200 and costs.

In justice to the Solvay Process Co., Detroit, Michigan, we wish to say they were in no way involved in the case.

Fertilizer Prices

The rise of commercial fertilizer prices during the past two or three years has put every consumer on his mettle to keep the cost of fertilizing down as low as possible. One means has been the curtailment, and in some cases, the abandonment of the use of potash, especially on the heavier soils and in connection with crops that are not heavy potash feeders. The increased use of acid phosphate is undoubtedly due, in part, to this same effort to reduce the ever rising costs.

The temptation to buy low grade goods which sell at a lower price per ton is strong, even under normal conditions but in these abnormal times the tendency toward the lower grade fertilizers has seemed to be greater than ever. That this practice is unwise is shown in the following discussion of unit costs of the different forms of plant-food.

The "unit" method of computing values is commonly used in the fertilizer trade and the reader should get the meaning of the term and its application clearly in mind. One unit of plant-food is understood to mean one per cent on the basis of the ton and hence represents 20 pounds; thus, if a fertilizer contains one per cent of nitrogen it is said to carry one unit of nitrogen, if two per cent then there are two units of nitrogen in the ton and similarly for the other plant-foods. A fertilizer, then, analyzing 1% nitrogen, 8% phosphoric acid and 1% potash carries one, eight and one units of the plant-foods in the order named. Knowing the ton price of a fertilizer containing but one of the plant-foods, as for instance an acid phosphate, the unit price of the particular food element is determined by dividing the ton price by the number representing the percentage.

During the past year five different grades of acid phosphate were sold in the State. Of the 18 per cent and 20 per cent grades only one or two

samples were collected and consequently are not included in the discussion. Several samples of other grades were found and the average selling price and unit cost of phosphoric acid in each is shown in the following table:

UNIT COST OF PHOSPHORIC ACID

Grade	Average Retail Price.	Unit Cost of Phosphoric Acid.
10%	$23.13	$2.31
14%	25.58	1.83
16%	26.61	1.66

It is readily seen that as the grade or percentage of available phosphoric acid increases the cost per unit of plant-food decreases.

Assuming that $1.66 represents the average unit cost, to the consumer, of available phosphoric acid in 16% acid phosphate during the past year, we can now determine the cost per unit of ammonia in the various grades of ammoniated phosphate. This is done by multiplying the number of units of phosphoric acid by the price per unit. This result is then subtracted from the price per ton which gives the cost of the total amount of ammonia. If now we divide this by the number of units of ammonia, we obtain the cost of ammonia per unit in that particular lot of fertilizer. As an example let us assume a 1-12-0 fertilizer selling at $34.12 per ton. Multiply the number of units of phosphoric acid by the price per unit (12×$1.66=$19.92) which represents the value of the available phosphoric acid. Now subtract this result from the selling price ($34.12—$19.92=$14.20) and the result will be the cost of one unit of ammonia. The cost per unit of nitrogen is determined by dividing the unit cost of ammonia by the factor 0.82 ($14.20÷0.82=$17.32).

The unit cost of ammonia in the various grades of ammoniated phosphate sold in the State during the past year is shown in the following table:

Formula.	Average Retail Price *per ton.*	Cost of Phosphoric Acid at $1.66 *per unit.*	Cost of Ammonia per unit.	Cost of Nitrogen per unit.
½-12-0	$28.36	$19.92	$16.88	$20.59
1-10-0	30.91	16.60	14.31	17.45
1-12-0	32.75	19.92	12.83	15.58
2- 8-0	35.92	13.28	12.64	15.41
2-12-0	38.64	19.92	9.96	12.15

Some objection might be raised to this method of arriving at the unit cost of ammonia, especially in using the lowest phosphoric acid unit value for determining the cost of the phosphoric acid in the mixtures. However, the cost of manufacturing any of the various grades of ammoniated phosphate, exclusive of materials, should not be much greater than the cost of making 16% acid phosphate for the process is practically the same, except that in making ammoniated phosphate the ammonia-bearing material is mixed with the rock phosphate before the sulfuric acid is added. Whatever extra overhead expense is incurred therefor should rightly be charged up to the ammonia. On the other hand if the ammonia-phosphate mixture

is made by adding an ammoniate to a ready-made acid phosphate by the dry-mix process then it would be necessary to use a 16% phosphate in most cases and the extra cost of the mixture over and above the same amount of 16% acid phosphate should be charged to the ammonia. Furthermore, it is not our purpose to attempt to show actual values but to demonstrate the difference in cost of the plant-food to the farmer between the low and high grade fertilizers. In the case of the ammoniated phosphates sold in the State during the year the difference between the cost of the ammonia in the ½-12-0 and the 2-12-0 formulas is very marked and a glance at the above table should deter any thoughtful person from purchasing the lower grade fertilizers. We are not in any way criticising the manufacturers' prices on the lower grade formulas since, for aught we know, the retail prices that prevailed last year on these formulas may be as low as it would be possible to make them and provide a fair profit to the manufacturers. However, we do know that those farmers who purchased the lower grade formulas paid a much higher cost per unit of plant-food than did those who bought the higher grade goods.

In arriving at the unit cost of the potash we have followed the same method as used in determining the unit cost of ammonia except that we used the phosphate-potash mixtures. There was a much smaller amount of these mixtures sold in Michigan during 1918 than of the ammoniated phosphates but the number of samples obtained were probably just as large in proportion to the amount sold so that the average retail prices should be as representative as in the case of the ammoniated phosphates.

Grade.	Average Retail Price.	Cost of Phosphoric Acid at $1.66 per unit.	Cost of Potash per unit.
0-10-1	$30 83	$16 60	$14 23
0-12-1	30 94	19 92	11 02
0-12-2	36 00	19 92	8 04

Here, also, we find that in the higher grade or higher analysis mixtures the cost per unit of potash is considerably lower than in the lower grade goods.

Now, if we use the lowest unit values for ammonia, phosphoric acid and potash that have been obtained in the various cases (ammonia $9.96, phosphoric acid $1.66, potash $8.04) and compute the value of the various complete fertilizers we obtain some very interesting data.

Formula.	Computed Value per ton.	Average Retail Price per ton.
1 -8 -5	$63 44	$60 00
2 -12 -2	55 92	54 00
2¼-8 -2	54 26	49 00
2 -8 -2	49 28	46 00
2 -8 -1	41 24	40 29
1 -8 -2	39 32	40 94
1 -12 -1	37 92	39 01
1 -10 -½	30 64	35 92
1 -9 -1	32 94	35 73
1 -8 -1	31 28	35 59
½ -8 -1	26 30	36 50*
½ -10 -1	29 62	33 07
1 -7 -1	29 62	33 86
½-11½ -½	28 09	32 10

*Fall prices only.

A study of the above table shows, first, that the average retail price of the higher grade formuias was lower, in every case, than the computed value, and second, the average retail price of the lower grade formulas (those that contain one per cent or less of ammonia with a correspondingly low percentage of potash) is higher than the computed value. The difference varies from $1.09 in the 1-12-1 formula to $10.20 in the ½-8-1 formula. The average difference is considerable and it is evident that in buying these low grade formulas the farmer pays the fertilizer companies for a service that is of no value. This service may be accounted for by the filler that would be required to dilute the higher grades or to the cost of handling a larger amount of low grade ammoniate or potash material. Furthermore in the lower grade fertilizer the overhead expense, or cost of manufacture exclusive of materials, freight, etc., constitutes a larger percentage of the selling price than in the higher grade fertilizers, all of which accounts for the higher unit cost of the plant-food.

Once more we wish to call attention to the fact that the computed values given in this table do not necessarily represent the true market values but in comparison with the retail prices they demonstrate that the low grade fertilizers are the most expensive. Also we make no recommendation as to the type of fertilizer one should use, this depends upon many factors which cannot be discussed here but having determined upon the type of fertilizer, be it acid phosphate or a complete fertilizer, the foregoing data demonstrate the advisability of buying the higher grade formulas. Furthermore the analytical results published in the following pages show that the higher grade complete fertilizers, as a general rule, carry a better quality of ammoniate or, in other words, the nitrogen in the higher grade complete fertilizers would, in general, be more readily available than the nitrogen of the low grade fertilizers.

In connection with the foregoing discussion it is interesting to note that a movement is on foot among the manufacturers to reduce the number of fertilizer brands and eliminate all those with less than 14 per cent of available plant-food.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	American Agricultural Chemical Co., Detroit, Mich.		'G	....	....	....	1.6	....	....	12.00	....
A 2014	Amo. Phos. Fertilizer	Mayville	'F	0.92	0.45	0.36	1.73	16.40	2.96	13.44	....
A 2224	Amo. Phos. Fertilizer	Brighton		1.13	0.39	0.26	1.78	15.33	2.10	13.23	....
A 2209	Amo. Phos. Fertilizer	Beech		1.09	0.45	0.23	1.77	15.10	2.02	13.08	....
A 2636*	Amo. Phos. Fertilizer	Plymouth		1.11	0.50	0.12	1.73	16.30	1.00	15.30	....
A 2640*	Amo. Phos. Fertilizer	Beech		0.96	0.52	0.33	1.81	15.35	1.16	14.19	....
			Av.	1.04	0.46	0.26	1.76	15.70	1.85	13.85	....
	Beet Fertilizer 1916	....	'G	....	....	....	0.82	....	....	9.00	1.00
			'G	....	....	....	0.82	....	....	8.00	2.00
A 2195	Favorite Potash Fertilizer	Ithaca	'F	0.34	0.29	0.27	0.90	11.05	1.38	9.67	2.40
A 2223	Favorite Potash Fertilizer	Brighton		0.56	0.27	0.32	1.15	10.75	1.38	9.37	2.10
A 2426	Favorite Potash Fertilizer	Richmond		0.40	0.31	0.33	1.04	11.65	1.44	10.21	2.16
A 2578*	Favorite Potash Fertilizer	Blissfield		0.54	0.24	0.22	1.00	10.70	2.00	8.70	2.33
A 2653*	Favorite Potash Fertilizer	Batavia		0.49	0.26	0.25	1.00	11.00	2.10	8.90	1.92
			Av.	0.47	0.27	0.28	1.02	11.03	1.65	9.38	2.18
			'G	....	....	....	1.65	27.00	....	....	....
A 1976*	Fine Ground Bone	Harlem	'F	0.48	0.84	0.45	1.77	30.30	....	....	....
A 2083	Fine Ground Bone	Glendora		0.16	0.96	0.52	1.64	28.50	....	....	....
A 2435	Fine Ground Bone	Almont		0.40	0.75	0.61	1.76	29.90	....	....	....
			Av.	0.35	0.85	0.52	1.72	29.57	....	....	....
	Michigan Bean Grower 1916	....	'G	....	....	....	1.65	....	....	8.00	1.00
			'G	....	....	....	15.00	....	....	....	....
A 2600*	Nitrate of Soda	Marshall	'F	....	....	....	15.28	....	....	....	....
			'G	....	....	....	0.82	....	....	8.00	1.00
A 2329	New York State Special 1916	Hillsdale	'F	0.29	0.33	0.42	1.04	11.90	1.30	10.60	1.52
A 2424	New York State Special 1916	Richmond		0.46	0.28	0.31	1.07	11.80	1.76	10.04	1.21
A 2565*	New York State Special 1916	Willis		0.46	0.22	0.29	0.97	11.55	2.16	9.39	1.06
			Av.	0.40	0.28	0.35	1.03	11.75	1.74	10.01	1.26
			'G	....	....	....	0.82	....	....	10.00	....
A 1759	1 and 10 Compound	Ruth	'F	0.41	0.27	0.34	1.02	13.45	2.38	11.07	....
A 1777	1 and 10 Compound	Bad Axe		0.46	0.28	0.33	1.07	13.30	1.76	11.54	....
A 1941*	1 and 10 Compound	Millington		0.48	0.24	0.29	1.01	13.55	2.18	11.37	....

A 2030	1 and 10 Compound	Drenthe		0.51	0.25	0.25	1.01	13.40	2.02	11.38	....
A 2192	1 and 10 Compound	Ithaca		0.50	0.23	0.28	1.01	13.60	2.34	11.26	....
A 2208	1 and 10 Compound	Beech		0.51	0.28	0.31	1.10	14.05	2.16	11.89	....
A 2580*	1 and 10 Compound	Blissfield		0.41	0.21	0.33	0.95	13.20	1.00	12.20	....
A 2607*	1 and 10 Compound	Carleton		0.50	0.24	0.31	1.05	13.25	1.90	11.35	....
A 2614*	1 and 10 Compound	Beech		0.52	0.23	0.30	1.05	13.80	2.28	11.52	....
			Av.	0.48	0.25	0.30	1.03	13.51	2.00	11.51	....
	Bradley's Brands.		'G	....	....	....	....	....	....	***10.00***	....
A 1760	Acid Phosphate	Ruth	'F	....	....	....	....	12.10	0.92	11.18	....
A 2194	Acid Phosphate	Ithaca		....	....	....	....	17.90	0.92	16.98	....
			Av.	....	....	....	....	15.00	0.92	14.08	....
			'G	....	....	....	....	....	....	***16.00***	....
A 1761	16% Acid Phosphate	Ruth	'F	....	....	....	....	20.20	1.52	18.68	....
A 2193	16% Acid Phosphate	Ithaca		....	....	....	....	19.93	1.04	18.89	....
A 2226	16% Acid Phosphate	Brighton		....	....	....	....	18.40	1.06	17.34	....
A 2561*	16% Acid Phosphate	Milan		....	....	....	....	18.35	0.38	17.97	....
A 2566*	16% Acid Phosphate	Willis		....	....	....	....	18.50	0.56	17.94	....
			Av.	....	....	....	....	19.07	0.91	18.16	....
			'G	....	....	....	***0.82***	....	....	***10.00***	***1.00***
A 2510	All Crops Fertilizer	Farmington	'F	0.56	0.15	0.24	0.95	13.10	1.28	11.82	1.20
			'G	....	....	....	***1.65***	....	....	***8.00***	....
A 2131	B. D. Sea Fowl Guano 1918	Galesburg	'F	0.70	0.60	0.51	1.81	11.45	2.26	9.19	....
A 2351	B. D. Sea Fowl Guano 1918	Adrian		1.24	0.65	0.36	2.25	11.90	2.24	9.66	....
			Av.	0.97	0.63	0.43	2.03	11.68	2.25	9.43	....
			'G	....	....	....	***1.65***	....	....	***8.00***	***1.00***
A 2113	B. D. Sea Fowl Guano with Pot.	Kalamazoo	'F	0.73	0.51	0.49	1.73	11.75	1.86	9.89	1.41
			'G	....	....	....	***0.82***	....	....	***8.00***	***1.00***
A 2225	Dissolved Bone Phosphate with Potash 1916	Brighton	'F	0.37	0.22	0.34	0.93	11.55	1.06	10.49	1.22
			'G	....	....	....	***0.82***	....	....	***7.00***	***1.00***
A 2114	Niagara Phosphate	Kalamazoo	'F	0.56	0.21	0.21	0.98	9.85	0.78	9.07	1.36
A 2352	Niagara Phosphate	Adrian		0.52	0.23	0.19	0.94	9.50	0.76	8.74	1.32
A 2395	Niagara Phosphate	Millington		0.63	0.16	0.19	0.98	9.50	1.14	8.36	1.21
A 2584*	Niagara Phosphate	Clayton		0.53	0.19	0.21	0.93	9.05	0.46	8.59	1.22
A 2636*	Niagara Phosphate	Carleton		0.45	0.26	0.20	0.91	9.35	1.48	7.87	1.28
			Av.	0.54	0.21	0.20	0.95	9.45	0.92	8.53	1.28
			'G	....	....	....	....	....	....	***14.00***	....
A 2029	Soluble Dissolved Bone Phos.	Drenthe	'F	....	....	....	....	17.65	2.08	15.57	....
A 2130	Soluble Dissolved Bone Phos.	Galesburg		....	....	....	....	16.30	0.66	15.64	....

**Fall Samples.*
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued.

Laboratory No.	Manufacturer and Trade Name.	Sampled at	Nitrogen.				Phosphoric Acid.			Potash.
			As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Bradley's Brands—Con.									
A 2196	Soluble Dissolved Bone Phos.	*Ithaca*					16.50	0.98	15.52	
A 2290	Soluble Dissolved Bone Phos.	Milan					18.25	1.50	16.75	
A 2467	Soluble Dissolved Bone Phos.	*Swartz Creek*					17.50	0.98	16.52	
		Av.					17.24	1.24	16.00	
		'G				0.82			8.00	1.00
A 2129	Special Potash Fertilizer 1916	Galesburg 'F	0.58	0.24	0.25	1.07	11.60	1.64	9.96	1.26
A 2191	Special Potash Fertilizer 1916	*Ithaca*	0.54	0.19	0.26	0.98	11.70	1.38	10.32	1.32
		Av.	0.56	0.22	0.25	1.03	11.65	1.51	10.14	1.29
	Crocker's Brands.									
		'G							10.00	
A 2428	10% Acid Phosphate	*Richmond* 'F					14.80	1.12	13.68	
		'G				1.65			8.00	1.00
A 2310	Am. Wheat & Corn Phos. 1916	Beech 'F	0.73	0.66	0.45	1.84	11.80	1.90	9.90	1.21
A 2311	Am. Wheat & Corn Phos. 1916	*Batavia*	0.66	0.63	0.48	1.77	11.15	2.00	9.15	1.23
		Av.	0.70	0.65	0.46	1.81	11.48	1.95	9.53	1.22
		'G				1.65			8.00	
A 1832	Ammoniated Wheat and Corn Phosphate No. 2	Coral 'F	0.79	0.82	0.37	1.98	12.85	3.02	9.83	
	Bean Grower	'G				1.65			8.00	1.00
		'G				0.82			10.00	1.00
A 2655*	Complete Fertilizer	Detroit 'F	0.60	0.11	0.23	0.94	13.15	1.32	11.83	1.27
		'G							14.00	
A 1762	Dissolved Bone Phosphate	Ruth 'F					18.00	1.32	16.68	
A 1958*	Dissolved Bone Phosphate	Croswell					16.50	0.30	16.20	
A 2016	Dissolved Bone Phosphate	*Fremont*					17.40	1.98	15.42	
		Av.					17.30	1.20	16.10	
		'G				0.82			7.00	1.00
A 2429	General Crop Phosphate	Richmond 'F	0.50	0.23	0.21	0.94	9.55	0.84	8.71	1.12
		'G							16.00	
A 2015	High Grade Phosphate	*Fremont* 'F					19.60	1.94	17.66	

A 2211	High Grade Phosphate........	Beech........		....	....	....	....	19.40	1.06	18.34	....
A 2417	High Grade Phosphate........	St. Clair......		....	....	....	....	18.74	1.08	17.66	....
			Av.	....	....	....	....	19.25	1.36	17.89	....
			'G	....	....	....	**0.82**	....	....	**9.00**	**1.00**
A 2443	New Rival Am. Superphos. 1916	Elba..........	'F	0.57	0.20	0.28	1.05	13.10	1.50	11.60	1.28
A 2608*	New Rival Am. Superphos. 1916	Carleton......		0.54	0.20	0.23	0.97	12.55	2.38	10.17	1.26
			Av.	0.56	0.20	0.26	1.01	12.83	1.94	10.89	1.27
			'G	....	....	....	**0.82**	....	....	**9.00**	**1.00**
A 2270	Sugar Beet Fertilizer..........	Carleton......	'F	0.51	0.27	0.29	1.07	10.75	1.12	9.63	1.40
			'G	....	....	....	**0.82**	....	....	**8.00**	**1.00**
A 1776	Universal Grain Grower 1916..	Bad Axe......	'F	0.43	0.23	0.38	1.04	10.75	1.20	9.55	1.21
A 2312	Universal Grain Grower 1916..	Batavia......		0.42	0.29	0.36	1.07	11.05	1.04	10.01	1.28
A 2579*	Universal Grain Grower 1916..	Blissfield.....		0.41	0.19	0.35	0.95	10.30	1.46	8.84	1.04
			Av.	0.42	0.24	0.36	1.02	10.70	1.23	9.47	1.18
	Michigan Carbon Works Brands										
			'G	....	....	....	**0.82**	....	....	**8.00**	**1.00**
A 1754	A-1 Potash Fertilizer 1916.....	Saginaw......	'F	0.47	0.24	0.37	1.08	10.90	1.18	9.72	1.08
A 1922*	A-1 Potash Fertilizer 1916.....	Ithaca........		0.47	0.25	0.32	1.04	12.05	1.52	10.53	1.19
A 1928*	A-1 Potash Fertilizer 1916.....	Carson City...		0.36	0.24	0.35	0.95	10.35	1.38	8.97	1.24
A 1980*	A-1 Potash Fertilizer 1916.....	Riverdale.....		0.50	0.25	0.25	1.00	11.55	2.38	9.17	1.17
A 2180	A-1 Potash Fertilizer 1916.....	Middleton....		0.36	0.22	0.33	0.91	11.05	0.98	10.07	1.38
A 2197	A-1 Potash Fertilizer 1916.....	Ithaca........		0.51	0.22	0.34	1.07	10.15	1.56	8.59	1.42
A 2306	A-1 Potash Fertilizer 1916.....	Dundee.......		0.18	0.32	0.32	1.02	11.34	1.04	10.30	1.13
A 2604*	A-1 Potash Fertilizer 1916.....	Carleton......		0.39	0.22	0.25	0.86	11.05	1.52	9.53	1.86
A 2619*	A-1 Potash Fertilizer 1916.....	Maybee.......		0.37	0.25	0.25	0.87	10.90	1.72	9.18	1.90
			Av.	0.40	0.25	0.31	0.98	11.04	1.48	9.56	1.37
			'G	....	....	....	**0.82**	....	....	**10.00**	....
A 1753	New Standard Fertilizer.......	Saginaw......	'F	0.46	0.31	0.38	1.15	13.55	1.72	11.83	....
A 1846*	New Standard Fertilizer.......	Vriesland.....		0.62	0.27	0.26	1.15	14.35	2.15	12.20	....
A 1859*	New Standard Fertilizer.......	Caledonia....		0.56	0.27	0.22	1.05	11.95	1.20	10.75	....
A 1891*	New Standard Fertilizer.......	Conklin......		0.44	0.17	0.27	0.88	13.75	0.98	12.77	....
A 2093	New Standard Fertilizer.......	Three Oaks...		0.37	0.25	0.25	0.87	13.63	2.12	11.51	....
A 2134	New Standard Fertilizer.......	Hastings......		0.50	0.28	0.34	1.12	13.50	1.70	11.80	....
A 2230	New Standard Fertilizer.......	South Lyon...		0.47	0.23	0.24	0.94	13.35	1.50	11.85	....
A 2522*	New Standard Fertilizer.......	Jonesville.....		0.51	0.27	0.24	1.02	12.85	1.32	11.53	....
A 2570*	New Standard Fertilizer.......	Azalia........		0.54	0.26	0.27	1.07	12.85	2.02	10.83	....
			Av.	0.50	0.26	0.27	1.03	13.31	1.64	11.67	....
			'G	....	....	....	**0.82**	....	....	**7.00**	**1.00**
A 1855*	Red Line Complete Manure...	Zeeland......	'F	0.48	0.32	0.24	1.04	9.60	2.10	7.50	1.19
A 2319	Red Line Complete Manure...	Jonesville.....		0.45	0.22	0.20	0.87	9.50	0.94	8.56	1.36

***Fall Samples.**
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at.	Nitrogen.				Phosphoric Acid.			Potash.
			As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Michigan Carbon Work Brand—Con.									
A 2422	Red Line Complete Manure...	Richmond....	0.60	0.17	0.20	0.97	9.65	1.12	8.53	1.42
A 2521*	Red Line Complete Manure...	Jonesville.....	0.43	0.31	0.21	0.95	9.45	1.92	7.53	1.03
		Av.	0.49	0.26	0.21	0.96	9.55	1.52	8.03	1.25
		'G							14.00	
A 1807	Red Line Phosphate..........	South Haven.. 'F					16.70	2.04	14.66	
A 1931*	Red Line Phosphate..........	Riverdale.....					16.40	0.58	15.82	
A 2231	Red Line Phosphate..........	South Lyon...					17.28	1.40	15.88	
A 2285	Red Line Phosphate..........	Maybee......					17.40	1.42	15.98	
		Av.					16.95	1.36	15.59	
		'G							16.00	
A 1847*	Superior Acid Phosphate......	Vriesland..... 'F					19.40	0.55	18.85	
A 1856*	Superior Acid Phosphate......	Zeeland......					19.00	0.55	18.45	
A 1866*	Superior Acid Phosphate......	Conklin......					19.00	0.42	18.58	
A 2065	Superior Acid Phosphate......	Rockford.....					19.95	1.88	18.07	
A 2080	Superior Acid Phosphate......	Benton Harbor					19.64	1.84	17.80	
A 2085	Superior Acid Phosphate......	Glendora.....					17.70	0.74	16.96	
A 2097	Superior Acid Phosphate......	Lawrence.....					18.23	1.06	17.17	
A 2297	Superior Acid Phosphate......	Belleville.....					20.10	1.92	18.18	
A 2338	Superior Acid Phosphate......	Reading......					18.92	1.76	17.16	
A 2613*	Superior Acid Phosphate......	Belleville.....					17.65	0.70	16.95	
		Av.					18.96	1.14	17.82	
		'G				1.65			12.00	
A 1809	Triaton Fertilizer.............	Covert....... 'F	1.16	0.41	0.27	1.84	15.60	2.22	13.38	
A 1942*	Triaton Fertilizer.............	Caro.........	1.16	0.58	0.17	1.91	15.85	1.98	13.87	
A 2044	Triaton Fertilizer.............	Ross.........	0.96	0.40	0.30	1.66	15.35	2.36	12.99	
A 2137	Triaton Fertilizer.............	Hastings......	1.21	0.39	0.31	1.91	15.33	2.46	12.87	
A 2298	Triaton Fertilizer.............	Belleville.....	1.10	0.40	0.26	1.76	15.37	2.24	13.13	
A 2458	Triaton Fertilizer.............	Holt.........	1.00	0.58	0.40	1.98	16.64	2.20	14.44	
A 2571*	Triaton Fertilizer.............	Azalia........	1.15	0.38	0.35	1.88	16.45	1.92	14.53	
		Av.	1.11	0.45	0.29	1.85	15.79	2.19	13.60	
		'G							12.00	1.00
A 2181	Usemore Fertilizer............	Middleton.... 'F					14.15	0.70	13.45	1.44

A 2423	Usemore Fertilizer	Richmond		....	....	....	....	12.90	0.60	12.30	0.92
			Av.	....	....	....	....	13.53	0.65	12.88	1.18
			'G	....	....	....	....	....	....	10.00	....
A 1960*	Wolverine Phosphate	Silverwood	'F	....	....	....	....	12.10	0.86	11.24	....
A 2136	Wolverine Phosphate	Hastings		....	....	....	....	11.75	1.12	10.63	....
A 2271	Wolverine Phosphate	*Carleton*		....	....	....	....	12.92	1.04	11.88	....
			Av.	....	....	....	....	12.26	1.01	11.25	....
	Michigan Carbon Works Homestead Brands.										
	Bean Fertilizer	....	'G	....	....	....	*1.65*	....	....	**8.00**	**1.00**
			'G	....	....	....	**0.82**	....	....	**10.00**	**1.00**
A 1808	Bialode Fertilizer	Covert	'F	0.52	0.26	0.25	1.03	13.50	1.32	12.18	1.22
A 2087	Bialode Fertilizer	Glendora		0.41	0.20	0.32	0.93	13.85	1.54	12.31	1.33
A 2199	Bialode Fertilizer	St. Louis		0.53	0.16	0.26	0.95	13.10	1.16	11.94	1.40
A 2342	*Bialode Fertilizer*	*Hillsdale*		*0.71*	*0.15*	*0.22*	*1.08*	*13.70*	*1.52*	*12.18*	*1.58*
A 2460	Bialode Fertilizer	Holt		0.43	0.25	0.29	0.97	13.32	1.24	12.08	1.40
			Av.	0.52	0.20	0.27	0.99	13.49	1.36	12.13	1.39
			'G	....	....	....	**1.65**	....	....	**8.00**	....
A 2086	Bone Black Fertilizer 1918	Glendora	'F	0.52	0.67	0.51	1.70	11.90	2.70	9.20	....
A 2098	Bone Black Fertilizer 1918	Lawrence		1.23	0.54	0.29	2.06	12.35	2.28	10.07	....
A 2318	Bone Black Fertilizer 1918	Jonesville		1.06	0.52	0.37	1.95	11.85	1.28	10.57	....
A 2372	*Bone Black Fertilizer 1918*	Morenci		1.07	0.59	0.33	1.99	12.15	2.26	9.89	....
			Av.	0.97	0.58	0.38	1.93	12.06	2.13	9.93	....
			'G	....	....	....	**1.65**	....	....	**8.00**	**1.00**
A 2079	Bone Black Fertilizer with Pot.	Benton Harbor	'F	0.67	0.64	0.56	1.87	10.70	1.84	8.86	1.32
A 2135	Bone Black Fertilizer with Pot.	Hastings		0.55	0.67	0.44	1.66	11.60	2.00	9.60	1.14
A 2461	Bone Black Fertilizer with Pot.	Howell		1.56	0.07	0.20	1.83	10.84	0.30	10.54	1.27
			Av.	0.93	0.46	0.40	1.79	11.05	1.38	9.67	1.24
			'G	....	....	....	**0.82**	....	....	**9.00**	**1.00**
A 2505	Bone Black Sugar Beet Fertilizer	Bay City	'F	0.55	0.17	0.30	1.02	11.52	1.02	10.50	1.03
			'G	....	....	....	**0.82**	....	....	**8.00**	**2.00**
A 2434	Special Potash Fertilizer	Almont	'F	0.35	0.24	0.35	0.94	10.90	1.18	9.72	2.41
A 2459	*Special Potash Fertilizer*	Holt		0.38	0.20	0.42	1.00	11.20	1.30	9.90	2.20
			Av.	0.37	0.22	0.39	0.97	11.05	1.24	9.81	2.31
			'G	....	....	....	**0.82**	....	....	**9.00**	**1.00**
A 2371	Sugar Beet Fertilizer 1916	Ottawa Lake	'F	0.42	0.22	0.31	0.95	11.80	1.26	10.54	1.00
A 2416	Sugar Beet Fertilizer 1916	Marine City		0.50	0.21	0.29	1.00	12.15	1.70	10.46	1.14
			Av.	0.46	0.22	0.30	0.98	11.98	1.48	10.50	1.07

*Fall Samples.

'*Abbreviations for Guaranteed and Found.*

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Niagara Brands.										
			'G	....	....	....	....	....	....	10.00	....
A 2502	Acid Phosphate 10%	Capac	'F	....	....	....	....	12.25	0.92	11.33	....
	Bean Grower	....	'G	....	....	....	1.65	....	....	8.00	1.00
			'G	....	....	....	....	....	....	12.00	1.00
A 1796	Crown Phosphate and Potash	Imlay City	'F	....	....	....	....	14.90	1.26	13.64	1.01
A 2310	Crown Phosphate and Potash	Batavia		....	....	....	....	15.15	1.18	13.97	1.26
			Av.	....	....	....	....	15.03	1.22	13.81	1.14
			'G	....	....	....	....	....	....	14.00	....
A 2501	Dissolved Bone Phosphate	Davison	'F	....	....	....	....	17.50	0.84	16.66	....
	General Crop Fertilizer	....	'G	....	....	....	0.82	....	....	10.00	1.00
			'G	....	....	....	0.82	....	....	7.00	1.00
A 2425	Grain and Grass Grower	Richmond	'F	0.53	0.21	0.20	0.94	9.45	0.86	8.59	1.28
			'G	....	....	....	....	....	....	16.00	....
A 2427	High Grade Phosphate	Richmond	'F	....	....	....	....	18.30	0.68	17.62	....
			'G	....	....	....	0.82	....	....	9.00	1.00
A 2289	Wheat and Corn Producer 1916	Milan	'F	0.50	0.27	0.27	1.04	12.75	1.80	10.95	1.30
	Northwestern Horseshoe Brands.										
			'G	....	....	....	0.82	....	....	10.00	1.00
A 2239	Acidulated Bone Phos. & Potash	Saline	'F	0.41	0.20	0.32	0.93	12.28	1.24	11.04	1.21
			'G	....	....	....	0.82	....	....	7.00	1.00
A 2074	Animal Bone Phos. Manure	Hartford	'F	0.43	0.24	0.20	0.87	9.30	1.10	8.20	1.34
A 2240	Animal Bone Phos. Manure	Saline		0.54	0.19	0.18	0.91	9.00	0.98	8.02	1.27
A 2339	Animal Bone Phos. Manure	Reading		0.56	0.20	0.19	0.95	9.20	0.64	8.56	1.26
A 2541*	Animal Bone Phos. Manure	Montgomery		0.47	0.29	0.21	0.97	8.95	2.10	6.85	1.26
			Av.	0.50	0.23	0.20	0.93	9.12	1.21	7.91	1.28
	Bean Special 1916	....	'G	....	....	....	1.65	....	....	8.00	1.00
			'G	....	....	....	1.65	....	....	8.00	1.00
A 2202	Corn and Wheat Grower 1916	Imlay City	'F	0.74	0.74	0.40	1.88	11.10	1.82	9.28	1.14

			'G	....	....	....	1.65	....	....	8.00	....
A 2073	Corn and Wheat Grower 1918..	Hartford.....	'F	1.08	0.48	0.38	1.94	12.60	1.96	10.64	....
A 2218	Corn and Wheat Grower 1918..	Plymouth.....		1.03	0.60	0.39	2.02	12.33	1.86	10.47	....
A 2336	Corn and Wheat Grower 1918..	Montgomery..		1.04	0.53	0.28	1.85	12.30	2.06	10.24	....
A 2356	Corn and Wheat Grower 1918..	Adrian.......		1.08	0.70	0.21	1.99	12.60	2.00	10.60	....
A 2543*	Corn and Wheat Grower 1918..	Montgomery..		0.98	0.46	0.33	1.77	12.35	2.42	9.93	....
			Av.	1.04	0.55	0.32	1.91	12.44	2.66	10.38	....
			'G	....	....	....	1.65	....	....	12.00	....
A 2450	Dissolved Am. Bone Phosphate	Corunna......	'F	0.93	0.58	0.29	1.80	17.10	1.90	15.20	....
			'G	....	....	....	0.82	....	....	10.00	....
A 1797	F. and F. Fertilizer..........	Imlay City...	'F	0.50	0.23	0.28	1.01	12.95	2.02	10.93	....
A 1848*	F. and F. Fertilizer..........	Forest Grove..		0.64	0.27	0.23	1.14	15.10	2.70	12.40	....
A 1924*	F. and F. Fertilizer..........	Pompeii......		0.57	0.25	0.26	1.08	13.60	2.22	11.38	....
A 2075	F. and F. Fertilizer..........	Hartford.....		0.38	0.25	0.32	0.95	13.25	2.10	11.15	....
A 2244	F. and F. Fertilizer..........	Ida..........		0.41	0.33	0.33	1.07	13.10	1.56	11.54	....
A 2256	F. and F. Fertilizer..........	Petersburg....		0.48	0.20	0.29	0.97	13.85	2.88	10.97	....
A 2516*	F. and F. Fertilizer..........	Coldwater....		0.51	0.27	0.24	1.02	13.35	2.42	10.93	....
A 2534*	F. and F. Fertilizer..........	Reading......		0.63	0.23	0.32	1.18	14.15	2.30	11.85	....
			Av.	0.52	0.25	0.28	1.05	13.67	2.28	11.39	....
			'G	....	....	....	1.65	....	....	8.00	1.00
A 2138	Garden City Superphosphate with Potash..............	Coloma......	'F	0.87	0.65	0.38	1.90	11.10	1.88	9.22	1.21
A 2233	Garden City Superphosphate with Potash..............	South Lyon...		0.64	0.27	0.69	1.60	10.90	1.84	9.06	1.36
			Av.	0.76	0.46	0.54	1.75	11.00	1.86	9.14	1.29
			'G	....	....	....	....	....	....	16.00	....
A 1798	16% Phosphate..............	Imlay City...	'F	....	....	....	....	19.15	1.34	17.81	....
A 1849*	16% Phosphate..............	Forest Grove..		....	....	....	....	17.70	0.35	17.35	....
A 2072	16% Phosphate..............	Hartford.....		....	....	....	....	19.57	2.04	17.53	....
A 2258	16% Phosphate..............	Petersburg....		....	....	....	....	19.83	2.02	17.81	....
A 2335	16% Phosphate..............	Montgomery..		....	....	....	....	19.18	1.68	17.50	....
A 2591*	16% Phosphate..............	Petersburg....		....	....	....	....	19.95	0.96	18.99	....
			Av.	....	....	....	....	19.19	1.36	17.83	....
			'G	....	....	....	0.82	....	....	8.00	2.00
A 1800	Two Potash Fertilizer.........	Imlay City...	'F	0.46	0.26	0.26	0.98	10.95	1.40	9.55	2.06
A 1826	Two Potash Fertilizer.........	Grant........		0.44	0.22	0.34	1.00	10.65	2.16	8.49	1.82
A 2232	Two Potash Fertilizer.........	South Lyon...		0.32	0.27	0.32	0.91	10.90	1.38	9.52	2.00
			Av.	0.41	0.25	0.30	0.96	10.83	1.65	9.18	1.96
			'G	....	....	....	0.82	....	....	8.00	1.00
A 1786	Potash Manure 1916..........	Cass City.....	'F	0.62	0.17	0.21	1.00	11.30	1.70	9.60	0.98
A 1920*	Potash Manure 1916..........	St. Johns.....		0.51	0.27	0.22	1.00	11.45	2.37	9.08	1.33

*Fall Samples.
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	Northwestern Horseshoe Brands—Con.										
A 1923*	Potash Manure 1916	Pompeii		0.44	0.30	0.26	1.00	12.20	2.42	9.78	1.04
A 2068	Potash Manure 1916	Holland		0.40	0.19	0.35	0.94	11.65	1.84	9.81	1.25
A 2357	Potash Manure 1916	Adrian		0.47	0.30	0.31	1.08	11.30	1.00	10.30	1.32
A 2451	Potash Manure 1916	Corunna		0.39	0.27	0.36	1.04	14.60	1.28	13.32	1.25
A 2637*	Potash Manure 1916	Plymouth		0.43	0.15	0.28	0.86	10.25	1.22	9.03	1.09
A 2659*	Potash Manure 1916	Elm		0.46	0.22	0.24	0.94	10.70	1.86	8.84	1.07
			Av.	0.47	0.23	0.28	0.98	11.68	1.71	9.97	1.17
			'G	....	....	....	....	....	....	10.00	....
A 2201	Quick Acting Phosphate	Imlay City	'F	....	....	....	....	12.05	0.88	11.17	....
A 2255	Quick Acting Phosphate	Petersburg		....	....	....	....	12.35	0.94	11.41	....
A 2590*	Quick Acting Phosphate	Petersburg		....	....	....	....	13.05	1.46	11.59	....
			Av.	....	....	....	....	12.48	1.09	11.39	....
			'G	....	....	....	....	....	....	14.00	....
A 1799	Square Deal Phosphate	Imlay City	'F	....	....	....	....	16.90	1.26	15.64	....
A 2245	Square Deal Phosphate	Ida		....	....	....	....	17.13	1.52	15.61	....
A 2592*	Square Deal Phosphate	Petersburg		....	....	....	....	16.95	0.60	16.35	....
A 2599*	Square Deal Phosphate	Ida		....	....	....	....	16.50	0.46	16.04	....
			Av.	....	....	....	....	16.87	0.96	15.91	....
			'G	....	....	....	0.82	....	....	9.00	1.00
A 2257	Sugar Beet Fertilizer 1916	Petersburg	'F	0.28	0.31	0.28	0.87	11.70	1.24	10.46	1.44
			'G	....	....	....	....	....	....	12.00	1.00
A 2241	XXX Fertilizer	Saline	'F	....	....	....	....	13.70	0.96	12.74	1.01
A 2259	XXX Fertilizer	Petersburg		....	....	....	....	14.60	1.06	13.54	0.98
A 2589*	XXX Fertilizer	Petersburg		....	....	....	....	14.60	0.52	14.08	1.05
			Av.	....	....	....	....	14.30	0.85	13.45	1.01
	Packers Boars Head Brands										
			'G	....	....	....	0.82	....	....	10.00	1.00
A 1825	Ammon. Bone Phos. and Potash	Kent City	'F	0.58	0.19	0.33	1.10	14.50	1.98	12.52	1.11
	Corn and Wheat Grower 1916	....	'G	....	....	....	1.65	....	....	8.00	1.00

			'G				1.65			8.00	
A 1977*	Corn and Wheat Grower 1918	Harlem	'F	0.82	0.51	0.34	1.67	11.95	1.56	10.39	
A 2439	Corn and Wheat Grower 1918	Washington		0.58	0.74	0.44	1.76	11.62	1.38	10.24	
			Av.	0.70	0.63	0.39	1.72	11.79	1.47	10.32	
			'G				0.82			7.00	1.00
A 2275	Faultless Grain Grower	Waltz	'F	0.55	0.18	0.20	0.93	10.15	0.70	9.45	1.36
A 2349	Faultless Grain Grower	Osseo		0.53	0.22	0.19	0.94	9.20	0.82	8.38	1.15
			Av.	0.54	0.20	0.20	0.94	9.68	0.76	8.92	1.26
			'G							14.00	
A 2507	Gilt Edge Phosphate	Devereaux	'F					17.10	0.78	16.32	
A 2563*	Gilt Edge Phosphate	Willis						16.25	0.16	16.09	
			Av.					16.68	0.47	16.21	
			'G				0.82			10.00	
A 1831	New Compound	Holland	'F	0.54	0.20	0.27	1.01	14.20	2.42	11.78	
A 1851*	New Compound	Nunica		0.53	0.24	0.25	1.02	13.03	1.85	11.18	
A 1884*	New Compound	Kent City		0.47	0.26	0.24	0.97	15.70	2.28	13.42	
A 1909*	New Compound	Lake Odessa		0.48	0.23	0.30	1.01	13.05	1.86	11.19	
A 2212	New Compound	Elm		0.59	0.20	0.28	1.11	13.80	2.32	11.48	
A 2229	New Compound	Brighton		0.28	0.27	0.36	0.91	13.40	1.48	11.92	*
A 2276	New Compound	Waltz		0.48	0.29	0.31	1.08	12.93	1.90	11.03	
A 2542*	New Compound	Montgomery		0.64	0.20	0.29	1.13	14.25	2.78	11.47	
A 2562*	New Compound	Willis		0.46	0.23	0.31	1.00	13.70	1.64	12.06	
			Av.	0.50	0.24	0.29	1.03	13.78	2.05	11.73	
			'G				0.82			8.00	2.00
A 2350	New Compound and Pot. Fert.	Osseo	'F	0.41	0.23	0.33	0.97	11.25	1.26	9.99	1.98
			'G							12.00	1.00
A 2277	Phospotash Fertilizer	Waltz	'F					13.95	1.24	12.71	1.24
			'G							16.00	
A 1850*	16% Phosphate	Nunica	'F					18.50	0.40	18.10	
A 1908*	16% Phosphate	Lake Odessa						18.75	0.34	18.41	
A 2189	16% Phosphate	Ashley						18.42	0.82	17.60	
A 2228	16% Phosphate	Brighton						18.85	1.86	16.99	
			Av.					18.63	0.86	17.77	
			'G							10.00	
A 1830	Soluble Phosphate	Holland	'F					13.50	0.86	12.64	
A 2564*	Soluble Phosphate	Willis						12.30	0.20	12.10	
			Av.					12.90	0.53	12.37	

*Fall Samples.

'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	*Manufacturer and Trade Name.*	Sampled at	Nitrogen.				Phosphoric Acid.			Potash.
			As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Packers Boars Head Brands—Con.									
		'G				1.65			12.00	
A 2441	Success Fertilizer	Washington... 'F	0.52	0.83	0.42	1.77	15.70	1.64	14.06	
	Sugar Beet Grower 1916	'G				0.82			9.00	1.00
		'G				0.82			8.00	1.00
A 1934*	Sure Growth Pot. Manure 1916	Alma 'F	0.51	0.20	0.27	0.98	11.40	2.60	8.80	0.92
A 2188	Sure Growth Pot. Manure 1916	Ashley	0.44	0.29	0.28	1.01	10.80	1.14	9.66	1.42
A 2190	Sure Growth Pot. Manure 1916	North Star	0.47	0.25	0.26	0.98	11.60	1.82	9.78	1.27
A 2227	Sure Growth Pot. Manure 1916	Brighton	0.38	0.25	0.34	0.97	11.35	1.18	10.17	1.25
A 2440	Sure Growth Pot. Manure 1916	Washington	0.39	0.25	0.34	0.98	10.60	1.38	9.22	1.00
		Av.	0.44	0.25	0.30	0.99	11.15	1.62	9.53	1.17
		'G				1.65			8.00	1.00
A 2503	World of Good Superphosphate with Potash	Bay City 'F	0.87	0.57	0.47	1.91	11.50	2.22	9.28	1.52
	Armour Fertilizer Works, Chicago, Ill.									
		'G							16.00	
A 1987*	Acid Phosphate	Brown City... 'F					17.50	0.30	17.20	
A 2089	Acid Phosphate	Three Oaks					19.60	3.08	16.52	
A 2174	Acid Phosphate	Lake Odessa					18.20	1.86	16.34	
A 2483	Acid Phosphate	Tecumseh					20.43	2.34	18.09	
A 2629*	Acid Phosphate	Ypsilanti					17.75	0.16	17.59	
		Av.					18.70	1.55	17.15	
		'G				1.65			10.00	
A 2116	Ammoniated Phosphate No. 2	Kalamazoo... 'F	0.57	0.64	0.34	1.64	14.00	2.97	11.03	
A 2325	Ammoniated Phosphate No. 2	Litchfield	0.51	0.72	0.31	1.54	13.15	2.64	10.51	
		Av.	0.54	0.68	0.37	1.59	13.58	2.81	10.77	
		'G				1.65	27.00			
A 1912*	Bone Meal	Mulliken 'F	0.34	0.75	0.78	1.87	28.20			
A 1918*	Bone Meal	Eagle	0.41	0.97	0.47	1.85	27.30			
A 2284	Bone Meal	Maybee	0.57	0.48	0.87	1.92	28.15			
A 2326	Bone Meal	Litchfield	0.76	0.98	0.36	2.10	26.83			
A 2548*	Bone Meal	Charlotte	0.70	0.64	0.44	1.78	28.60			
		Av.	0.56	0.76	0.58	1.90	27.82			

			'G	...	...	...	...	...	...	10.00	...
A 1968*	Cereal Phosphate	Brown City	'F	...	...	...	...	11.00	0.36	10.64	...
			'G	...	...	...	1.65	...	...	8.00	2.00
A 1824	Grain Grower	Nashville	'F	0.61	0.52	0.27	1.40	9.90	2.00	7.90	1.91
A 2405	Grain Grower	Silverwood		0.39	0.39	0.24	1.02	13.15	1.90	11.25	1.10
			Av.	0.50	0.45	0.26	1.21	11.53	1.95	9.58	1.52
			'G	...	...	...	0.82	...	...	8.00	2.00
A 2151	Grain and Bean Special	Carson City	'F	0.24	0.34	0.30	0.88	11.35	1.46	9.89	1.94
A 2171	Grain and Bean Special	Clarksville		0.27	0.36	0.18	0.81	10.00	1.04	8.96	2.12
A 2283	Grain and Bean Special	Maybee		0.37	0.35	0.21	0.93	11.68	0.96	10.72	1.52
			Av.	0.29	0.35	0.23	0.27	11.01	1.15	9.86	1.86
			'G	...	...	...	0.82	...	...	8.00	1.00
A 1788	Michigan Special	Capac	'F	0.35	0.33	0.26	0.94	10.50	1.16	9.34	0.58
A 1866*	Michigan Special	Vermontville		0.48	0.28	0.11	0.87	10.30	1.40	8.90	1.01
A 1913*	Michigan Special	Mulliken		0.40	0.35	0.27	1.02	10.50	1.72	8.78	1.78
A 2090	Michigan Special	Three Oaks		0.23	0.32	0.22	0.77	9.53	1.14	8.39	0.83
A 2115	Michigan Special	Kalamazoo		0.38	0.41	0.21	1.00	10.50	1.92	8.58	0.82
A 2173	Michigan Special	Clarksville		0.34	0.37	0.22	0.93	11.20	1.92	9.28	0.89
A 2237	Michigan Special	Ann Arbor		0.17	0.33	0.29	0.79	10.15	1.52	8.63	0.93
A 2342	Michigan Special	Ypsilanti		0.40	0.45	0.25	1.10	9.53	1.28	8.25	1.19
A 2368	Michigan Special	Bay City		0.33	0.34	0.20	0.87	10.90	2.00	8.90	0.79
A 2464"	Michigan Special	Capac		...	...	...	0.98	10.12	0.97	9.15	0.75
			Av.	0.34	0.35	0.24	0.93	10.32	1.50	8.82	0.96
			'G	...	...	...	...	...	...	10.00	1.00
A 2148	Phosphate and Potash Special	Butternut	'F	...	...	...	...	11.00	0.58	10.42	1.00
A 2176	Phosphate and Potash Special	Sunfield		...	...	...	...	11.70	0.60	11.10	0.62
A 2243	Phosphate and Potash Special	Ypsilanti		...	...	...	...	10.33	0.58	9.75	0.57
A 2272	Phosphate and Potash Special	Carleton		...	...	...	...	10.50	0.50	10.00	0.58
A 2317	Phosphate and Potash Special	Allen		...	...	...	...	10.50	0.46	10.04	0.64
A 2547*	Phosphate and Potash Special	Charlotte		...	...	...	...	12.00	1.44	10.56	1.40
			Av.	...	...	...	...	11.02	0.69	10.31	0.80
			'G	...	...	...	3.30	...	...	8.00	1.00
A 2118	Special Celery & Truck Grower	Kalamazoo	'F	1.60	0.74	0.24	2.58	11.35	1.41	9.94	1.96
			'G	...	...	...	1.65	...	...	8.00	1.00
A 1823	Special Grain Grower	Nashville	'F	0.78	0.50	0.33	1.61	11.30	2.76	8.54	0.92
A 2126	Special Grain Grower	Decatur		0.80	0.57	0.39	1.76	10.50	2.41	8.09	0.99
A 2142	Special Grain Grower	Coloma		0.57	0.66	0.35	1.58	10.90	1.80	9.10	1.42
			Av.	0.72	0.58	0.35	1.65	10.90	2.32	8.58	1.11
			'G	...	...	...	0.82	...	...	8.00	3.00
A 2389	Standard	Bay City	'F	0.42	0.36	0.20	0.98	9.55	1.32	8.23	2.41

*Fall Samples.
'Abbreviations for Guaranteed and Found. "Duplicate sample of A 1788.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at	Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	***Armour Fertilizer Works*—Continued.**									
		'G							**14.00**	
A 1838*	Star Phosphate	Coopersville 'F					18.55	2.32	16.23	
A 2140	Star Phosphate	Coloma					16.55	0.66	15.89	
A 2238	Star Phosphate	Ann Arbor					13.98	0.28	13.70	
A 2273	Star Phosphate	Carleton					15.83	0.14	15.69	
A 2650*	Star Phosphate	St. Clair					16.35	0.64	15.71	
		Av.					16.25	0.81	15.44	
		'G				**0.82**			**7.00**	**1.00**
A 1789	Wheat, Corn and Oats Special	Capac 'F	0.25	0.25	0.26	0.76	9.20	1.02	8.13	1.00
A 1929*	Wheat, Corn and Oats Special	Butternut	0.45	0.31	0.22	0.98	10.15	2.46	7.69	0.88
A 2051	Wheat, Corn and Oats Special	Coopersville	0.22	0.35	0.23	0.80	9.30	1.94	7.36	0.83
A 2091	Wheat, Corn and Oats Special	Three Oaks	0.31	0.27	0.22	0.80	9.10	1.06	8.04	0.92
A 2149	Wheat, Corn and Oats Special	Butternut	0.33	0.30	0.20	0.83	9.65	2.63	7.02	0.99
A 2172	Wheat, Corn and Oats Special	Clarksville	0.31	0.33	0.22	0.86	10.45	1.90	8.55	0.88
A 2274	Wheat, Corn and Oats Special	Carleton	0.30	0.30	0.21	0.81	10.90	1.72	9.18	0.71
A 2175	Wheat, Corn and Oats Special	Lake Odessa	0.32	0.36	0.22	0.90	8.40	1.12	7.28	1.18
A 2520*	Wheat, Corn and Oats Special	Allen	0.29	0.35	0.24	0.88	10.25	2.02	8.23	1.26
A 2546*	Wheat, Corn and Oats Special	Charlotte	0.29	0.37	0.31	0.97	10.05	2.10	7.95	1.16
		Av.	0.31	0.32	0.23	0.86	9.75	1.80	7.95	0.98
		'G				**0.82**			**9.00**	**1.00**
A 1822	1-9-1 Fertilizer	Nashville 'F	0.28	0.34	0.26	0.88	12.85	1.52	11.33	0.84
		'G				**0.82**			**10.00**	
A 2628*	1-10 Fertilizer	Ypsilanti 'F	0.24	0.33	0.44	1.01	12.35	1.52	10.83	
		'G				**0.82**			**12.00**	**1.00**
A 2177	1-12-1 Fertilizer	Sunfield 'F	0.48	0.39	0.17	1.04	14.30	1.44	12.86	1.24
A 2652*	1-12-1 Fertilizer	Montgomery	0.32	0.33	0.32	0.97	14.85	1.44	13.41	1.11
		Av.	0.40	0.36	0.25	1.01	14.58	1.44	13.14	1.18
		'G				**2.47**			**8.00**	**1.00**
A 2117	3-8-1 Fertilizer	Kalamazoo 'F	1.15	0.67	0.25	2.07	11.30	1.37	9.93	1.51
		'G				**3.71**			**7.00**	**3.00**
A 2387	4½-7-3 Fertilizer	Bay City 'F	2.24	0.84	0.41	3.49	10.55	2.08	8.47	3.45

	Tuscarora Brands.										
			'G	....	....	....	....	....	....	14.00	....
A 2002	Acid Phosphate..............	Cadillac......	'F	....	....	....	....	15.94	0.18	15.76	....
A 2488	Acid Phosphate..............	Burton.......		....	....	....	....	17.65	0.47	17.18	....
			Av.	....	....	....	....	16.79	0.32	16.47	....
			'G	....	....	....	....	....	....	10.00	1.00
A 2486	Phosphate and Potash Special..	Burton.......	'F	....	....	....	....	11.15	0.62	10.53	0.51
			'G	....	....	....	0.82	....	....	8.00	1.00
A 1844*	Spec. C'rn, Whe't & Be'n Gr'w'r	Zeeland......	'F	0.29	0.38	0.19	0.86	11.20	2.30	8.90	1.20
A 1979*	Spec. C'rn, Whe't & Be'n Gr'w'r	Decatur......		0.44	0.28	0.19	0.91	10.00	1.64	8.36	1.02
A 2001*	Spec. C'rn, Whe't & Be'n Gr'w'r	Cadillac......		0.50	0.38	0.20	1.08	10.30	0.66	9.64	0.95
A 2094	Spec. C'rn, Whe't & Be'n Gr'w'r	New Buffalo..		0.33	0.31	0.24	0.88	11.00	1.92	9.08	0.72
A 2487	Spec. C'rn, Whe't & Be'n Gr'w'r	Burton........		0.22	0.32	0.27	0.81	9.08	1.46	7.62	0.83
			Av.	0.36	0.33	0.22	0.91	10.32	1.60	8.72	0.94
	Special Standard.............	....	'G	....	....	....	1.65	....	....	8.00	1.00
	Armour Fertilizer Works Chicago,, Ill.										
			'G	....	....	....	1.65	....	....	8.00	2.00
A 2003	Standard....................	Cadillac......	'F	0.81	0.65	0.45	1.91	13.95	2.50	11.45	3.29
			'G	....	....	....	1.65	....	....	10.00	....
A 1821	Tankage and Phosphate.......	Byron Center.	'F	0.86	0.75	0.38	1.99	13.05	3.18	9.87	....
A 2489	Tankage and Phosphate.......	Burton.......		0.58	0.62	0.51	1.71	13.55	2.58	10.97	....
			Av.	0.72	0.69	0.44	1.85	13.30	2.88	10.42	....
			'G	....	....	....	0.82	....	....	10.00	....
A 1845	1-10 Fertilizer..............	Zeeland......	'F	0.31	0.29	0.30	0.90	12.50	1.40	11.10	....
	R. Binder Co., Battle Creek, Mich.										
	Blood and Bone.............	....	'G	....		....	5.25	13.17	....	....	....
	E. Burton, St. Joseph, Mich.										
			'G	....	....	....	3.00	....	....	12.00	....
A 2087	Meat and Bone Phosphate.....	St. Joseph....	'F	0.70	1.49	1.26	3.45	16.65	5.26	11.39	....
	Calumet Fertilizer Co., New Albany, Ind.										
	Calumet 14% Acid Phosphate..	....	'G	....	....	....	....	....	....	14.00	....
	Calumet Coburn's Special with with Potash............	....	'G	....	....	....	0.60	....	....	8.50	0.50
	Calumet Special Dissolved Bone and Potash...........	....	'G	....	....	....	....	....	....	13.00	1.00

*Fall Samples.
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at	Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash Total.
	Darling & Company, Chicago, Ill.									
		'G	…	…	…	…	…	…	16.00	…
A 1767	16% Acid Phosphate	Minden City 'F	…	…	…	…	18.20	1.30	16.90	…
A 1834	16% Acid Phosphate	Sparta	…	…	…	…	22.00	3.04	18.96	…
A 1878*	16% Acid Phosphate	Fillmore Centre	…	…	…	…	19.60	1.80	17.80	…
A 1896*	16% Acid Phosphate	Burnips Corners	…	…	…	…	19.70	1.86	17.84	…
A 2011	16% Acid Phosphate	Casnovia	…	…	…	…	18.45	1.06	17.39	…
A 2057	16% Acid Phosphate	Nunica	…	…	…	…	19.02	1.08	17.94	…
A 2221	16% Acid Phosphate	Brighton	…	…	…	…	18.55	1.22	17.33	…
		Av.	…	…	…	…	19.36	1.62	17.74	…
		'G	…	…	…	1.65	…	…	12.00	1.00
A 2004	Big Harvest	Mt. Pleasant 'F	0.48	0.72	0.57	1.77	16.90	4.08	12.82	1.20
A 2058	Big Harvest	Galien	0.40	0.80	0.61	1.81	15.70	4.52	11.18	1.29
		Av.	0.44	0.76	0.59	1.79	16.30	4.30	12.00	1.25
		'G	…	…	…	2.47	…	…	8.00	1.00
A 2023'	Farmers Favorite	Grand Rapids 'F	0.26	0.26	0.35	0.87	10.95	1.80	9.15	2.58
A 2124	Farmers Favorite	Decatur	1.58	0.09	0.18	1.85	10.23	2.57	7.66	1.09
A 2146	Farmers Favorite	Lakeview	0.56	1.40	0.86	2.82	12.50	3.50	9.00	1.16
A 2203	Farmers Favorite	Beech	1.43	0.06	0.13	1.62	12.55	2.06	10.49	0.97
		Av.	0.96	0.46	0.38	1.80	11.56	2.48	9.08	1.45
		'G	…	…	…	1.65	…	…	12.00	…
A 2042	General Crop	Holland 'F	0.55	0.65	0.48	1.68	14.45	3.54	10.91	…
A 2513*	General Crop	Vicksburg	0.76	0.38	0.33	1.47	16.33	4.94	11.39	…
		Av.	0.66	0.51	0.41	1.58	15.39	4.24	11.15	…
		'G	…	…	…	0.82	…	…	9.00	1.00
A 1768	Grain Grower	Minden City 'F	0.23	0.13	0.16	0.52	10.85	2.20	8.65	0.99
A 1944*	Grain Grower	Caro	0.30	0.52	0.09	0.91	9.97	2.65	7.32	1.05
A 2005	Grain Grower	Mt. Pleasant	0.41	0.27	0.36	1.04	13.90	3.80	10.10	1.17
A 2010	Grain Grower	Casnovia	0.29	0.15	0.19	0.63	12.25	2.48	9.77	0.98
A 2021	Grain Grower	Grand Rapids	0.31	0.17	0.31	0.79	12.40	2.88	9.52	0.93
A 2054	Grain Grower	Nunica	0.31	0.13	0.36	0.80	11.30	2.66	8.64	1.11
A 2530*	Grain Grower	Reading	0.40	0.33	0.24	0.97	11.95	3.17	8.78	0.94
		Av.	0.32	0.24	0.25	0.81	11.80	2.83	8.97	1.02

		'G	...	...	...	0.82	...	...	12.00	...
A 1877*	Half and Half Brand	Fillmore Center 'F	0.31	0.38	0.25	0.94	25.18	13.17	12.01	...
A 2012	Half and Half Brand	Casnovia	0.28	0.34	0.25	0.87	24.10	11.00	13.10	...
A 2125	Half and Half Brand	Decatur	0.26	0.46	0.26	0.98	24.25	12.19	12.06	...
A 2164	Half and Half Brand	Sparta	0.27	0.34	0.29	0.90	23.70	9.30	14.40	...
A 2337	Half and Half Brand	Reading	0.43	0.34	0.20	0.97	24.27	12.76	11.51	...
		Av.	0.31	0.37	0.25	0.93	24.30	11.68	12.62	...
		'G	...	...	...	0.82	...	...	10.00	...
A 1876*	Little Giant	Fillmore Center 'F	0.25	0.12	0.49	0.86	14.40	4.30	10.10	...
A 1895*	Little Giant	Burnips Corner	0.26	0.40	0.27	0.93	10.75	2.46	8.29	...
A 2035	Little Giant	Holland	0.24	0.13	0.25	0.62	11.73	2.88	8.85	...
A 2040	Little Giant	Holland	0.22	0.15	0.27	0.64	12.70	4.75	7.95	...
A 2055	Little Giant	Nunica	0.26	0.37	0.41	1.04	12.42	3.44	8.98	...
A 2248	Little Giant	Ida	0.34	0.17	0.29	0.80	12.90	1.64	11.26	...
		Av.	0.26	0.22	0.33	0.81	12.48	3.24	9.24	...
		'G	...	...	...	2.06	1.00	...	...	1.00
A 2103	Pulverized Sheep Manure	Allegan 'F	0.43	0.26	0.97	1.66	2.00	0.36	1.64	1.48
A 2018	Pulverized Sheep Manure	Grand Rapids	0.39	0.43	1.14	1.96	2.15	0.20	1.95	2.16
A 2132	Pulverized Sheep Manure	Battle Creek	0.36	0.53	1.99	2.88	2.85	1.18	1.67	2.38
A 2452	Pulverized Sheep Manure	Lansing	0.66	0.51	1.55	2.72	2.75	1.28	1.47	2.38
		Av.	0.46	0.43	1.41	2.30	2.44	0.76	1.68	2.10
		'G	...	...	...	1.85	28.00	...	...	...
A 1798	Pure Ground Bone	Imlay City 'F	0.52	0.90	0.70	2.12	27.74	...	...	...
A 1833	Pure Ground Bone	Sparta	0.60	1.29	0.52	2.41	27.45	...	...	...
A 2024	Pure Ground Bone	Grand Rapids	0.68	0.90	0.44	2.02	29.50	...	...	...
A 2165	Pure Ground Bone	Sparta	0.46	0.91	0.68	2.05	28.85	...	...	...
A 2170	Pure Ground Bone	Muskegon Hts.	0.48	1.03	0.53	2.04	28.75	...	...	...
A 2484	Pure Ground Bone	Tecumseh	0.52	1.09	0.48	2.09	28.20	...	...	...
A 2550*	Pure Ground Bone	Lansing	0.58	0.92	0.59	2.09	29.00	...	...	...
		Av.	0.55	1.01	0.56	2.12	28.50	...	...	...
		'G	...	...	...	0.82	...	...	10.00	0.50
A 1932*	Sure Winner	Shepherd 'F	0.36	0.27	0.31	0.94	13.25	3.43	9.82	0.49
A 1943*	Sure Winner	Caro	0.33	0.19	0.21	0.73	14.00	3.36	10.64	0.52
A 2022	Sure Winner	Grand Rapids	0.32	0.17	0.32	0.81	12.50	4.04	8.46	0.72
A 2084	Sure Winner	Holland	0.29	0.13	0.24	0.66	13.00	2.86	10.14	0.50
A 2039	Sure Winner	Holland	0.25	0.23	0.38	0.86	12.30	2.60	9.70	0.52
A 2249	Sure Winner	Ida	0.22	0.18	0.29	0.69	12.63	3.98	8.65	0.60
A 2222	Sure Winner	Brighton	0.34	0.19	0.28	0.81	13.58	4.37	9.21	0.70
A 2512*	Sure Winner	Vicksburg	0.29	0.27	0.32	0.88	14.45	4.20	10.25	0.73
A 2529*	Sure Winner	Reading	0.31	0.31	0.25	0.87	13.25	2.84	10.41	0.90
		Av.	0.30	0.22	0.29	0.81	13.22	3.52	9.70	0.63

**Fall Samples.*
'Abbreviations for Guaranteed and Found. "Removed from sale by manufacturer.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Darling & Company—Con.		'G				0.82			8.00	2.00
A 1766	1–8–2	Minden City	'F	0.45	0.04	0.09	0.58	9.53	1.83	7.70	3.20
A 1794	1–8–2	Imlay City		0.43	0.21	0.30	0.94	10.50	2.28	8.22	1.81
A 2206	1–8–2	Mt. Pleasant		0.57	0.12	0.16	0.85	10.60	2.44	8.16	2.04
A 2041	1–8–2	Holland		0.46	0.11	0.19	0.76	9.75	2.38	7.37	1.91
			Av.	0.48	0.12	0.18	0.78	10.10	2.23	7.86	2.24
	Farmers Fertilizer Company, Columbus, Ohio.										
	Lillie's Favorite		'G				0.82			12.00	1.00
A 1963*	Lillie's Favorite	Merle Beach	'F	0.40	0.14	0.36	0.90	14.15	1.88	12.27	1.16
	Lillie's General Crop		'G				0.82			8.00	1.00
A 1964*	Lillie's General Crop	Merle Beach	'F	0.29	0.11	0.38	0.78	10.75	1.52	9.23	1.17
	Lillie's Humus Chief		'G				0.41			14.00	
	Lillie's Potash King		'G				0.82			8.00	3.00
A 1810	Lillie's Potash King	Kalamazoo	'F	0.93	0.04	0.13	1.10	10.00	1.82	8.18	3.20
A 1961*	Lillie's Potash King	Merle Beach		0.27	0.13	0.40	0.80	11.20	1.70	9.50	3.52
A 2187	Lillie's Potash King	Middleton		0.56	0.03	0.13	0.72	11.25	1.12	10.13	2.07
			Av.	0.58	0.07	0.22	0.87	10.82	1.55	9.27	2.93
	Lillie's Reliable Phosphate		'G							14.00	
A 2185	Lillie's Reliable Phosphate	Middleton	'F					15.95	1.04	14.91	
	Lillie's Special No. 1		'G				0.82			10.00	
A 1965*	Lillie's Special No. 1	Merle Beach	'F	0.26	0.11	0.29	0.66	15.15	1.84	13.31	
	Lillie's Special No. 2		'G							12.00	1.00
A 1962*	Lillie's Special No. 2	Merle Beach	'F					13.75	0.62	13.13	0.78
	Lillie's Special No. 3		'G				0.41			12.00	
	Lillie's Surprise		'G				1.64			12.00	
A 1811	Lillie's Surprise	Kalamazoo	'F	0.92	0.09	0.24	1.25	14.05	1.02	13.03	
A 2186	Lillie's Surprise	Middleton		0.89	0.11	0.32	1.32	13.25	1.20	12.05	
			Av.	0.91	0.10	0.28	1.29	13.65	1.11	12.54	

	Federal Chemical Company, Louisville, Ky.										
			'G				0.82			14.00	
A 2043	A-1 Corn and Wheat Fertilizer	Byron Center	'F	0.09	0.38	0.36	0.83	22.08	9.43	12.65	
A 2517*	A-1 Corn and Wheat Fertilizer	Quincy		0.37	0.09	0.21	0.67	19.65	6.25	13.40	
A 2523*	A-1 Corn and Wheat Fertilizer	Litchfield		0.30	0.11	0.43	0.84	19.25	4.98	14.27	
			Av.	0.26	0.19	0.33	0.78	20.33	6.89	13.44	
			'G				0.41			8.00	1.00
A 1939*	Bean, Beet and Onion Grower	Saginaw	'F	0.08	0.20	0.34	0.62	21.30	7.48	13.82	0.97
A 2495	Bean, Beet and Onion Grower	Pontiac		0.17	0.11	0.18	0.46	22.75	10.52	12.23	1.26
A 2533*	Bean, Beet and Onion Grower	Reading		0.08	0.25	0.41	0.74	21.75	11.76	9.99	1.36
			Av.	0.11	0.19	0.31	0.61	21.93	9.92	12.01	1.20
			'G				0.41			9.00	0.50
A 1940*	Daybreak Champ. Grain Gro'r	Vassar	'F	0.09	0.10	0.19	0.38	21.85	9.16	12.69	0.48
A 1951*	Daybreak Champ. Grain Gro'r	Harbor Beach		0.18	0.34	0.28	0.80	21.40	11.00	10.40	0.50
A 2234	Daybreak Champ. Grain Gro'r	Wayne		0.18	0.09	0.28	0.55	21.45	9.84	11.61	0.46
A 2421	Daybreak Champ. Grain Gro'r	St. Clair		0.09	0.27	0.12	0.48	24.00	13.20	10.80	0.29
			Av.	0.14	0.20	0.22	0.56	22.18	10.80	11.38	0.44
			'G							8.00	2.00
A 1938*	Daybreak Champ. Pot. Fert	Saginaw	'F					21.55	13.55	8.00	1.84
A 2491	Daybreak Champ. Pot. Fert	Leonard						17.90	9.30	8.60	1.65
A 2645*	Daybreak Champ. Pot. Fert	Rochester						19.65	7.45	12.20	1.86
			Av.					19.70	10.10	9.60	1.78
			'G				0.41			9.00	0.50
A 2410	Globe Tip Top Grain Grower	Chesaning	'F	0.15	0.07	0.19	0.41	22.85	12.22	10.63	0.54
			'G							8.00	2.00
A 2494	Globe Tip Top Potash Fertilizer	Pontiac	'F					19.25	10.38	8.87	1.26
			'G				1.65			10.00	
A 1900*	Half and Half Meal Mixture	Kalamazoo	'F	0.15	1.06	0.63	1.84	21.25	10.88	10.37	
			'G							10.00	
A 1897*	Half and Half Phosphate	Allegan	'F					25.55	9.46	16.09	
A 2071	Half and Half Phosphate	Hartford						25.81	16.29	9.52	
A 2305	Half and Half Phosphate	Dundee						27.00	16.40	10.60	
			Av.					26.12	14.05	12.07	
			'G							16.00	
A 1868*	High Grade Phosphate	Coopersville	'F					20.70	1.66	19.04	
A 2540*	High Grade Phosphate	Montgomery						21.95	4.28	17.67	
			Av.					21.33	2.97	8.36	

**Fall Samples.*
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	Federal Chemical Co.—Con.										
			'G	....	....	....	**0.82**	....	....	**8.00**	....
A 2490	King Crop Grower............	Leonard......	'F	0.00	0.38	0.48	0.86	21.65	7.70	3.95	....
			'G	....	....	....	**0.41**	....	....	**8**	
A 1968*	Liberty Wheat and Corn Grower	Clifford......	'F	0.10	0.12	0.23	0.45	21.30	8.50	12.80	1.22
A 1969*	Liberty Wheat and Corn Grower	North Branch.		0.03	0.17	0.32	0.52	19.40	10.80	8.60	1.04
A 2643*	Liberty Wheat and Corn Grower	Farmington...		0.11	0.08	0.26	0.45	20.10	8.36	11.74	1.43
			Av.	0.08	0.12	0.27	0.47	20.27	9.22	11.05	1.23
			'G	....	....	....	**0.41**	....	....	**11.00**	**1.00**
A 1756	Michigan Bean & Beet Special.	Elkton.......	'F	0.25	0.03	0.14	0.42	19.25	8.15	11.10	0.94
A 1774	Michigan Bean & Beet Special.	Harbor Beach.		0.14	0.06	0.25	0.45	12.30	1.10	11.20	0.98
A 1779	Michigan Bean & Beet Special.	Bad Axe......		0.23	0.02	0.10	0.35	19.75	6.84	12.91	0.65
A 1795	Michigan Bean & Beet Special.	Imlay City...		0.10	0.10	0.32	0.52	12.27	2.10	10.17	1.02
A 1952*	Michigan Bean & Beet Special.	Harbor Beach.		0.11	0.07	0.24	0.42	12.20	0.94	11.26	1.11
			Av.	0.17	0.06	0.20	0.43	15.16	3.83	11.33	0.94
			'G	....	....	....	**0.41**	....	....	**15.00**	....
A 2304	Nitro Phosphate.............	Dundee......	'F	0.18	0.09	0.10	0.37	17.90	1.74	16.16	....
			'G	....	....	....	**0.41**	....	....	**10.00**	**1.50**
A 2518*	Old Cap's Tobacco Compound.	Quincy.......	'F	0.15	0.09	0.25	0.49	19.75	6.06	13.69	1.14
			'G	....	....	....	....	....	....	**10.00**	**2.00**
A 1974*	Potash Special..............	Ionia.........	'F	....	....	....	....	14.20	1.14	13.06	1.29
			'G	....	....	....	**1.00**	**30.00**	....	....	....
A 2109	Pure Bone.....	Plainwell.....	'F	0.28	0.52	0.18	0.98	30.60	....	....	....
			'G	....	....	....	....	....	....	**10.00**	....
A 1921*	Special Phosphate Mixture....	Ithaca.......	'F	....	....	....	....	24.20	12.66	11.54	....
			'G	....	....	....	**0.41**	....	....	**10.00**	....
A 1763	Staff-O-Life Fertilizer.........	Minden City..	'F	0.32	0.03	0.02	0.37	23.53	12.84	10.69	....
A 1778	Staff-O-Life Fertilizer.........	Bad Axe......		0.17	0.50	0.20	0.87	21.08	12.58	8.50	....
A 2397	Staff-O-Life Fertilizer.........	Millington....		0.00	0.00	0.00	0.00	23.65	7.16	16.49	....
			Av.	0.16	0.18	0.07	0.41	22.75	10.86	11.89	....
			'G	....	....	....	**0.82**	....	....	**10.00**	....
	-- ---- ----	Imlay City...	'F	0.63	0.08	0.11	0.82	21.20	7.70	13.50	....

A 2033	Standard Meal Mixture	Holland		0.05	0.42	0.34	0.81	24.50	14.83	9.67	....
A 2147	Standard Meal Mixture	Lakeview		0.44	0.18	0.17	0.79	25.60	16.81	8.79	....
			Av.	0.37	0.23	0.21	0.81	23.76	13.11	10.65	....
			'G	....	....	....	0.41	....	....	11.50	0.50
A 1758	Standard Wheat & Corn Maker	Elkton	'F	0.27	0.02	0.10	0.39	20.60	8.04	12.56	0.43
A 1765	Standard Wheat & Corn Maker	Minden City		0.12	0.10	0.30	0.52	19.15	6.90	12.25	0.41
A 1867*	Standard Wheat & Corn Maker	Charlotte		0.17	0.10	0.25	0.52	19.55	5.78	13.77	0.43
A 1869*	Standard Wheat & Corn Maker	Coopersville		0.08	0.10	0.23	0.41	17.85	3.88	13.97	0.43
A 1898*	Standard Wheat & Corn Maker	Allegan		0.26	0.08	0.17	0.51	19.15	6.88	12.27	0.56
A 2028	Standard Wheat & Corn Maker	Zeeland		0.15	0.06	0.17	0.38	12.70	1.02	11.68	0.50
A 2031	Standard Wheat & Corn Maker	Holland		0.19	0.12	0.14	0.45	16.40	4.98	11.42	0.32
A 2053	Standard Wheat & Corn Maker	Coopersville		0.11	0.08	0.29	0.48	13.65	1.86	11.79	0.51
A 2070	Standard Wheat & Corn Maker	Hartford		0.04	0.11	0.24	0.39	19.60	7.82	11.78	0.76
A 2398	Standard Wheat & Corn Maker	Millington		0.19	0.14	0.07	0.40	22.60	9.56	13.04	0.51
A 2525*	Standard Wheat & Corn Maker	Litchfield		0.35	0.10	0.29	0.74	17.70	6.00	11.70	0.72
A 2536*	Standard Wheat & Corn Maker	Reading		0.21	0.09	0.29	0.59	19.75	6.02	13.73	0.48
A 2539*	Standard Wheat & Corn Maker	Montgomery		0.14	0.08	0.24	0.46	19.90	5.98	13.92	0.34
A 2572*	Standard Wheat & Corn Maker	Azalia		0.16	0.06	0.19	0.41	13.63	2.93	10.70	0.24
			Av.	0.18	0.09	0.21	0.48	18.02	5.55	12.47	0.47
			'G	....	....	....	....	....	....	10.00	1.00
A 1757	Sugar Beet Special	Pigeon	'F	....	....	....	....	21.70	11.68	10.02	0.10
A 1959*	Sugar Beet Special	Croswell		....	....	....	....	22.80	12.68	10.12	0.65
			Av.	....	....	....	....	22.25	12.18	10.07	0.38
			'G	....	....	....	....	....	....	10.00	....
A 1755	Twenty-Four Phosphate	Pigeon	'F	....	....	....	....	26.05	17.28	8.77	....
A 1764	Twenty-Four Phosphate	Minden City		....	....	....	....	25.90	15.72	10.18	....
A 1772	Twenty-Four Phosphate	Harbor Beach		....	....	....	....	25.98	16.97	9.01	....
A 1780	Twenty-Four Phosphate	Bad Axe		....	....	....	....	25.90	15.56	10.34	....
A 2032	Twenty-Four Phosphate	Holland		....	....	....	....	27.60	17.50	10.10	....
A 2052	Twenty-Four Phosphate	Coopersville		....	....	....	....	25.65	16.09	9.56	....
A 2056	Twenty-Four Phosphate	Nunica		....	....	....	....	27.00	15.32	11.68	....
			Av.	....	....	....	....	26.30	16.35	9.95	....
			'G	....	....	....	0.41	....	....	11.00	1.00
A 2433	Wheat and Corn Special	Romeo	'F	0.27	0.07	0.22	0.56	20.60	7.82	12.78	1.00
A 2524*	Wheat and Corn Special	Litchfield		0.03	0.10	0.36	0.49	17.35	4.04	13.31	1.08
A 2646*	Wheat and Corn Special	Romeo		0.22	0.07	0.19	0.48	19.25	7.84	11.41	0.83
			Av.	0.17	0.08	0.26	0.51	19.07	6.57	12.50	0.97
			'G	....	....	....	0.82	....	....	12.00	1.00
A 2411	Wheat and Grain Special	Chesaning	'F	0.47	0.06	0.20	0.73	14.42	1.94	12.48	0.74
			'G	....	....	....	....	....	....	10.00	....
A 1873*	400 Phosphate Mixture	Coopersville	'F	....	....	....	....	24.40	14.35	10.05	....

***Fall Samples.**
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Federal Chemical Co.—Con.										
A 1948*	400 Phosphate Mixture	Bad Axe						22.80	12.72	10.08	
A 2647*	400 Phosphate Mixture	St. Clair						24.20	12.64	11.56	
			Av.					23.80	13.24	10.56	
	The Fertile Chemical Co., Cleveland, Ohio.										
			'G					3.00			
A 2573*	Lime-Fertile	Adrian	'F					2.65			
A 2585*	Lime-Fertile	Petersburg						2.80			
A 2620*	Lime-Fertile	Maybee						2.55			
			Av.					2.67			
			'G				2.00			3.00	3.00
A 2471	Nitro Fertile	Jackson	'F	2.62			2.62	5.15		5.15	4.31
	Gleaner Clearing House Association, Detroit, Mich.										
	Ammonia and Phosphoric Acid		'G				1.65			10.00	
			'G							14.00	
A 2504	14% Acid Phosphate	Bay City	'F					15.40	0.65	14.75	
	Bean and Corn Grower		'G				0.82			10.00	1.00
	General Grower		'G				0.82			8.00	1.00
	Grain Special		'G				1.65			10.00	1.00
	Phosphoric Acid and Potash		'G							10.00	2.00
			'G				0.82			8.00	2.00
A 2506	Wolverine Pride	Freeland	'F	0.52	0.38	0.28	1.18	11.36	2.48	8.88	2.06
	The Independent Packers Fertilizer Co., Columbus, Ohio.										
			'G				0.82			11.00	0.50
A 1901*	No. 1 Independent Favorite	Elmdale	'F	0.12	0.17	0.45	0.74	13.90	1.20	12.70	0.56
[illegible]	No. 1 Independent Favorite	Riga		0.39	0.20	0.19	0.78	12.75	1.70	11.05	0.43

A 2442	No. 1 Independent Favorite...	Rochester....		0.29	0.22	0.25	0.76	12.85	1.96	10.89	0.71
A 2576*	No. 1 Independent Favorite...	Adrian.......		0.39	0.24	0.27	0.90	14.10	1.92	12.18	0.69
A 2582*	No. 1 Independent Favorite...	Blissfield.....		0.39	0.12	0.29	0.80	12.50	1.48	11.02	0.49
			Av.	0.32	0.19	0.29	0.80	13.22	1.65	11.57	0.58
	No. 2 Bone Meal and Phosphate Mixture..................	....	'G	....	....	....	0.82	....	....	8.00	1.00
			'G	....	....	....	0.82	....	....	8.00	0.50
A 2262	No. 3 C'rn, Whe't, Oats & Cl'ver	Erie.........	'F	0.31	0.23	0.21	0.75	10.15	1.52	8.63	0.52
A 2365	No. 3 C'rn, Whe't, Oats & Cl'ver	Blissfield.....		0.30	0.18	0.28	0.76	9.50	1.14	8.36	0.60
A 2404	No. 3 C'rn, Whe't, Oats & Cl'ver	Marlette.....		0.35	0.24	0.23	0.82	10.45	1.64	8.81	0.56
A 2575*	No. 3 C'rn, Whe't, Oats & Cl'ver	Adrian.......		0.34	0.23	0.26	0.83	9.65	1.75	7.90	0.56
A 2581*	No. 3 C'rn, Whe't, Oats & Cl'ver	Blissfield.....		0.42	0.19	0.23	0.84	9.35	0.82	8.53	0.32
			Av.	0.36	0.20	0.24	0.80	9.82	1.37	8.45	0.51
			'G	....	....	....	0.82	....	....	8.00	1.00
A 2268	No. 4 Independent Grain Special	Monroe......	'F	0.42	0.13	0.20	0.75	9.50	1.14	8.36	0.99
A 2353	No. 4 Independent Grain Special	Adrian.......		0.45	0.12	0.22	0.79	8.95	1.00	7.95	0.85
A 2364	No. 4 Independent Grain Special	Blissfield.....		0.14	0.21	0.42	0.77	10.45	1.92	8.53	0.95
			Av.	0.34	0.15	0.28	0.77	9.63	1.35	8.28	0.93
			'G	....	....	....	0.42	....	....	8.00	1.00
A 1945*	No. 4 Ind. Gr'n Spec. (Fall 1918)	Cass City....	'F	0.16	0.04	0.17	0.37	9.95	1.78	8.17	0.99
A 2526*	No. 4 Ind. Gr'n Spec. (Fall 1918)	North Adams.		0.11	0.09	0.12	0.32	10.10	1.86	8.24	0.71
A 2594*	No. 4 Ind. Gr'n Spec. (Fall 1918)	Deerfield.....		0.12	0.06	0.18	0.36	10.00	2.06	7.94	0.92
A 2631*	No. 4 Ind. Gr'n Spec. (Fall 1918)	Wayne.......		0.12	0.05	0.17	0.34	9.58	1.87	7.71	1.03
			Av.	0.13	0.06	0.16	0.35	9.91	1.89	8.02	0.91
			'G	....	....	....	1.64	....	....	10.00	....
A 2400	No. 5 Universal Crop.........	Marlette.....	'F	1.04	0.38	0.25	1.67	12.35	1.22	11.13	....
			'G	....	....	....	0.82	....	....	8.00	2.00
A 2269	No. 7 Corn and Wheat Special.	Monroe......	'F	0.46	0.10	0.23	0.79	9.80	1.20	8.60	2.01
A 2354	No. 7 Corn and Wheat Special.	Adrian.......		0.52	0.09	0.19	0.80	9.60	1.12	8.48	1.95
A 2370	No. 7 Corn and Wheat Special.	Riga.........		0.56	0.09	0.23	0.88	10.20	1.50	8.70	1.90
			Av.	0.51	0.09	0.22	0.82	9.87	1.28	8.59	1.95
			'G	....	....	....	0.41	....	....	10.00	....
A 2327	No. 8 Ammoniated Special....	North Adams.	'F	0.10	0.16	0.20	0.46	12.70	1.52	11.18	....
A 2402	No. 8 Ammoniated Special....	Marlette.....		0.05	0.11	0.25	0.41	12.45	2.56	9.89	....
A 2593*	No. 8 Ammoniated Special....	Deerfield.....		0.00	0.21	0.31	0.52	12.35	1.70	10.65	....
			Av.	0.05	0.16	0.25	0.46	12.50	1.93	10.57	....

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ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	The Independent Packers Fertilizer Co.—Con.		'G				0.41			12.00	
A 2263	No. 9 Ammoniated Phosphate	Erie	'F	0.04	0.16	0.26	0.46	14.70	2.00	12.70	
A 2403	No. 9 Ammoniated Phosphate	Mariette		0.08	0.10	0.23	0.41	14.25	1.98	12.27	
			Av.	0.06	0.13	0.25	0.44	14.48	1.99	12.49	
			'G							16.00	
A 2355	No. 11 High Grade Phosphate	Adrian	'F					17.85	3.30	14.55	
A 2577*	No. 11 High Grade Phosphate	Adrian						17.18	2.98	14.20	
			Av.					17.52	3.14	14.38	
A 2399	Michigan Bean & Truck Special	Mariette	'G				0.82			8.00	2.00
			'F	0.13	0.26	0.35	0.74	10.20	1.64	8.56	1.87
A 2363	Sugar Beet Special	Blissfield	'G				0.82			8.00	1.00
			'F	0.45	0.13	0.19	0.77	10.15	1.24	8.91	0.83
	International Agricultural Corporation, Cincinnati, O.		'G							16.00	
A 2026	16% Acid Phosphate	Hudsonville	'F					19.65	1.78	17.87	
A 2333	16% Acid Phosphate	Montgomery						19.18	1.08	18.10	
A 1843*	16% Acid Phosphate	Hudsonville						20.40	0.85	19.55	
A 1870*	16% Acid Phosphate	Coopersville						19.75	0.95	18.80	
A 1915*	16% Acid Phosphate	Grand Ledge						18.35	0.50	17.85	
			Av.					19.46	1.03	18.43	
			'G							18.00	
A 1860*	18% Acid Phosphate	Caledonia	'F					20.48	0.40	20.08	
A 2632*	18% Acid Phosphate	Manchester						19.30	1.24	18.06	
			Av.					19.89	0.82	19.07	
			'G				0.80			10.00	
A 1957*	Farmers' Favorite	Carsonville	'F	0.43	0.27	0.19	0.89	12.60	2.10	10.50	
A 2278	Farmers' Favorite	Willow		0.54	0.41	0.31	1.26	12.15	1.68	10.47	
A 2334	Farmers' Favorite	Montgomery		0.29	0.37	0.15	0.81	11.75	1.22	10.53	
A 2374	Farmers' Favorite	Morenci		0.28	0.36	0.26	0.90	12.05	1.34	10.71	
			Av.	0.39	0.35	0.23	0.97	12.14	1.59	10.55	

			'G				0.40			12.50	
A 2096	Garbage Tankage and Phos....	Lawrence.....	'F	0.18	0.26	0.14	0.58	13.50	1.06	12.44	
A 2468	Garbage Tankage and Phos....	Grand Ledge..		0.21	0.26	0.13	0.60	16.44	1.46	14.98	
			Av.	0.19	0.26	0.14	0.59	14.97	1.26	13.71	
			'G				0.80	22.00			
A 1872*	Special Wheat Fertilizer.......	Coopersville..	'F	0.50	0.31	0.14	0.85	24.20			
A 2406	Special Wheat Fertilizer.......	Mayville.....		0.41	0.13	0.41	0.95	24.40			
A 2583*	Special Wheat Fertilizer.......	Clayton......		0.40	0.15	0.25	0.80	23.60			
			Av.	0.44	0.20	0.27	0.90	24.07			
	Wheat, Corn and Oats Special..	....	'G				0.80			10.00	1.00
			'G				1.60			10.00	
A 2027	Buffalo Ammoniated Phosphate	Hudsonville..	'F	0.68	0.49	0.51	1.68	11.65	1.36	10.29	
			'G							10.00	1.00
A 1871*	Buffalo Buckeye Brand........	Coopersville..	'F					12.05	0.98	11.07	0.91
A 1916*	Buffalo Buckeye Brand........	Grand Ledge..						11.20	0.82	10.38	0.76
A 2462	Buffalo Buckeye Brand........	Grand Ledge..						11.52	1.14	10.38	1.10
A 2538*	Buffalo Buckeye Brand........	Montgomery..						10.85	0.64	10.21	0.68
			Av.					11.41	0.90	10.51	0.86
	Buffalo Complete Fertilizer....	....	G				1.60			8.00	1.00
			'G				0.80			8.00	1.00
A 1917*	Buffalo Crop Grower..........	Grand Ledge..	'F	0.37	0.27	0.29	0.93	10.55	1.44	9.11	0.91
A 2095	Buffalo Crop Grower..........	Lawrence.....		0.32	0.32	0.20	0.84	9.30	0.52	8.78	0.98
A 2332	Buffalo Crop Grower..........	Montgomery..		0.38	0.18	0.11	0.67	11.05	1.56	9.49	1.59
A 2380	Buffalo Crop Grower..........	Bay City.....		0.37	0.39	0.26	1.02	9.50	1.24	8.26	1.08
			Av.	0.36	0.29	0.22	0.87	10.10	1.19	8.91	1.14
			'G							14.00	
A 1978*	Buffalo Dissolved Phosphate...	West Olive...	'F					16.25	0.64	15.61	
			'G				0.80			13.00	
A 1842*	Buffalo Grain Grower.........	Hudsonville..	'F	0.36	0.38	0.28	1.02	15.00	1.05	13.95	
			'G				0.80			8.00	2.00
A 2330	Buffalo Grain and Grass Grower	Reading......	'F	0.34	0.27	0.20	0.81	11.40	0.84	10.56	2.04
A 2381	Buffalo Grain and Grass Grower	Bay City.....		0.51	0.34	0.22	1.07	9.00	0.78	8.22	2.03
			Av.	0.43	0.30	0.21	0.94	10.20	0.81	9.39	2.04
			'G							12.00	2.00
A 2331	Buffalo Phosphate and Potash..	Reading......	'F					13.48	0.90	12.58	2.20
			'G				1.60			8.00	2.00
A 2025	Buffalo Two-Eight-Two.......	Hudsonville..	'F	0.82	0.43	0.33	1.58	8.55	0.84	7.71	1.75

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ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at.	Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	The Jarecki Chemical Co., Sandusky, Ohio.									
		'G							16.00	
A 2250	Acid Phosphate	Petersburg 'F					19.93	0.58	19.35	
A 2293	Acid Phosphate	Belleville					17.45	2.44	15.01	
A 2362	Acid Phosphate	Blissfield					19.35	0.38	18.97	
		Av.					18.91	1.13	17.78	
		'G				0.82			10.00	
A 1889*	Ammoniated Phosphate	Conklin 'F	0.41	0.14	0.15	0.70	12.70	1.54	11.16	
A 2156	Ammoniated Phosphate	Sparta	0.27	0.26	0.27	0.80	12.15	1.06	11.0[illegible]	
A 2159	Ammoniated Phosphate	Coopersville	0.39	0.25	0.26	0.80	12.60	1.14	11.46	
A [illegible]40	Ammoniated Phosphate	Reading	0.25	0.25	0.27	0.77	12.70	1.00	11.70	
A [illegible]07	Ammoniated Phosphate	Mayville	0.45	0.24	0.12	0.81	13.00	1.28	11.72	
A 2596*	Ammoniated Phosphate	Ida	0.46	0.23	0.21	0.90	14.45	2.82	11.63	
		Av.	0.37	0.23	0.21	0.81	12.93	1.47	11.46	
		'G				1.65			12.00	
A 1887*	Cereala	Conklin 'F	0.98	0.25	0.19	1.42	14.95	1.34	13.61	
A 2292	Cereala	Belleville	1.14	0.27	0.18	1.59	14.10	0.86	13.24	
		Av.	1.06	0.26	0.19	1.51	14.53	1.10	13.43	
		'G							14.00	
A 2161	C. O. D. Phosphate	Coopersville 'F					18.90	1.08	17.82	
A 2288	C. O. D. Phosphate	Milan					18.70	0.90	17.80	
A 2296	C. O. D. Phosphate	French Landing					17.60	2.00	15.60	
A 2323	C. O. D. Phosphate	Litchfield					17.25	0.80	16.45	
A 2598*	C. O. D. Phosphate	Ida					16.50	0.56	15.94	
		Av.					17.79	1.07	16.72	
		'G				1.25			9.00	1.00
A 1820	L. Erie Guano with Phos. & Pot.	Breckenridge 'F	0.67	0.25	0.36	1.28	12.85	1.60	11.25	0.97
A 2295	L. Erie Guano with Phos. & Pot.	French Landing	0.95	0.16	0.20	1.31	11.35	0.70	10.65	1.09
A 2321	L. Erie Guano with Phos. & Pot.	Litchfield	0.94	0.14	0.16	1.24	10.95	0.66	10.29	1.16
A 2341	L. Erie Guano with Phos. & Pot.	Reading	0.89	0.15	0.18	1.22	10.85	0.62	10.23	0.91
A 2615*	L. Erie Guano with Phos. & Pot.	French Landing	0.85	0.10	0.11	1.06	12.45	1.88	10.57	1.15
		Av.	0.86	0.16	0.20	1.22	11.69	1.09	10.60	1.06

			'G	....	....	....	**0.41**	....	....	**10.00**	**1.00**
A 1839*	Little Giant	Coopersville		0.29	0.10	0.13	0.52	12.70	2.05	10.65	1.01
A 1914*	Little Giant	Grand Ledge		0.28	0.06	0.09	0.43	13.50	1.56	11.94	**0.86**
A 2155	Little Giant	Sparta		0.29	0.08	0.15	0.52	12.85	2.76	10.09	0.77
A 2160	Little Giant	Coopersville		0.31	0.06	0.08	0.45	13.05	1.16	11.89	**0.86**
A 2251	Little Giant	Petersburg		0.25	0.08	0.11	0.44	13.40	2.42	10.98	**0.49**
A 2264	Little Giant	Erie		0.29	0.07	0.13	0.49	11.75	2.55	**9.20**	**0.46**
A 2320	Little Giant	Litchfield		0.16	0.13	0.23	0.52	12.30	1.41	10.89	1.21
A 2597*	Little Giant	Ida		0.28	0.06	0.08	0.42	13.75	3.00	10.75	1.04
A 2609*	Little Giant	Waltz		0.25	0.13	0.11	0.49	13.20	2.48	10.72	1.40
			Av.	0.27	0.09	0.12	0.48	12.94	2.15	10.79	0.90
			'G	....	....	....	**0.82**	....	....	**12.00**	**1.00**
A 1888*	Middle West Formula	Conklin	'F	0.54	0.19	0.07	0.80	16.85	3.42	13.43	**0.71**
A 2322	Middle West Formula	Litchfield		0.56	0.12	0.11	0.79	14.60	1.96	12.64	1.14
			Av.	0.55	0.16	0.09	0.80	15.73	2.69	13.04	0.93
			'G	....	....	....	**0.82**	....	....	**9.00**	**1.00**
A 1804	Number One Formula	Saranac	'F	0.67	0.16	0.17	1.00	10.45	1.48	8.97	1.26
A 1840*	Number One Formula	Coopersville		0.52	0.13	0.19	0.84	12.00	1.30	10.70	1.26
A 1907*	Number One Formula	Lake Odessa		0.57	0.09	0.09	0.75	10.45	0.94	9.51	1.06
A 2158	Number One Formula	Sparta		0.43	0.20	0.24	0.87	11.95	1.22	10.73	**0.88**
A 2200	Number One Formula	Alma		1.00	0.21	0.15	1.36	11.80	1.04	10.76	1.48
A 2220	Number One Formula	Plymouth		0.52	0.20	0.29	1.01	11.55	1.62	9.93	1.23
A 2265	Number One Formula	LaSalle		0.39	0.18	0.24	0.81	11.43	2.63	**8.80**	1.08
A 2270	Number One Formula	Maybee		0.47	0.19	0.28	0.94	12.15	2.54	9.61	**0.78**
A 2614*	Number One Formula	French Landing		0.56	0.11	0.13	0.80	13.13	1.50	11.63	1.05
			Av.	0.57	0.16	0.20	0.93	11.66	1.59	10.07	1.12
			'G				**1.65**			**8.00**	
A 2497	Raw Bone Phosphate Mixture	Munger	'F	0.89	0.57	0.30	1.76	18.73	10.81	7.92	....
			'G	....	....	....	**0.82**	....	....	**9.00**	**1.00**
A 1819	Special Sugar Beet Grower	Breckenridge	'F	0.70	0.16	0.25	1.11	13.00	1.98	11.02	1.04
A 2498	Special Sugar Beet Grower	Bach		0.65	0.12	0.17	0.94	10.70	1.18	9.52	1.45
			Av.	0.68	0.14	0.21	1.03	11.85	1.58	10.27	1.25
			'G	....	....	....	**0.82**	....	....	**8.00**	**2.00**
A 1806	Tobacco and Truck Grower	Bradley	'F	0.41	0.21	0.19	0.81	10.90	0.84	10.06	2.75
A 1911*	Tobacco and Truck Grower	Woodbury		0.69	0.14	0.14	0.97	8.20	0.72	7.48	1.93
A 2219	Tobacco and Truck Grower	Plymouth		0.49	0.15	0.30	0.94	11.80	0.96	10.84	2.13
A 2280	Tobacco and Truck Grower	Maybee		0.38	0.21	0.16	0.75	11.60	1.10	10.50	**1.28**
A 2324	Tobacco and Truck Grower	Litchfield		0.72	0.12	0.17	1.01	8.73	0.78	7.95	2.10
			Av.	0.54	0.17	0.19	0.90	10.25	0.88	9.37	2.04

*Fall Samples.
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Michigan State Grange, Detroit, Mich.										
A 2654*	All Crops Special Fertilizer 1916	Palmyra......	'G 'F	.... 0.52	.... 0.31	.... 0.21	0.82 1.04	.... 11.65	.... 2.52	8.00 9.13	1.00 1.04
A 2432	Complete Manure............	Romeo.......	'G 'F	.... 0.56	.... 0.22	.... 0.19	0.82 0.97	.... 9.55	.... 0.76	7.69 8.79	1.00 1.20
A 1828	Corn and Oats Fertilizer......	Hopkins......	'G 'F	.... 0.84	.... 0.54	.... 0.47	1.65 1.85	.... 11.85	.... 3.06	8.00 8.79	....
A 1827 A 2509	High Grade Phos. *and* Potash.. High Grade Phos. and Potash..	Hopkins...... Chelsea......	'G 'F	....	....	....	....	.... 14.20 14.40	.... 0.82 1.16	12.00 13.38 13.24	1.00 0.91 1.04
			Av.	....	....	....	....	14.30	0.99	13.31	0.98
A 1[illegible] A 2206	I X Fertilizer............... I X Fertilizer...............	Hopkins...... Monroe......	'G 'F	.... 0.53 0.48	.... 0.28 0.23	.... 0.20 0.26	0.82 1.01 0.97	.... 15.20 13.20	.... 2.24 2.32	10.00 12.96 10.88	....
			Av.	0.50	0.26	0.23	0.99	14.20	2.28	11.92	....
A 2267 A 2455 A 2601*	Wheat Fertilizer No. 1........ Wheat Fertilizer No. 1........ Wheat Fertilizer No. 1........	Monroe...... St. Johns..... Monroe......	'G 'F	....	....	....	....	.... 17.55 17.08 15.70	.... 1.48 0.60 0.32	14.00 16.07 16.48 15.38	....
			Av.	....	....	....	....	16.78	0.80	15.98	....
	Wheat Fertilizer No. 2........	....	'G	....	....	....	....	....	....	*10.00*	....
	National Plant Food Co., Eau Claire, Wis.										
A 2453	Red Snapper................	*Lansing*......	'G 'F	.... 1.41	.... 2.05	.... 1.55	5.00 5.01	.... 12.44	.... 5.74	4.00 6.70	1.25 1.53
	Natural Guano Co., Aurora, Ill.										
	"Sheep's Head" Pulverized Sheep Manure..............	....	'G	....	....	....	2.25	....	....	1.00	1.50

	Nitrate Agencies Co., Columbus, Ohio.										
A 2066	N. A. C. Nitrate of Soda	Grand Rapids	'G				15.00				
			'F				15.32				
	Nu-Life Fertilizer Co., Chicago, Ill.										
	Nu-Life Fertilizer		'G					14.00			
	The Packers Fertilizer Co., Sandusky, Ohio.										
			'G							16 00	
A 1949*	Acid Phosphate	Harbor Beach	'F					17.70	0.68	19 02	
A 2418	Acid Phosphate	St. Clair						19.80	0.86	18.94	
A 2420	Acid Phosphate	Adair						18.42	0.88	17.54	
			Av.					18.64	0.81	17.83	
			'G							14.00	
A 2500	Acidulated Phosphate	Vassar	'F					19.30	0.86	18.44	
			'G				0.82			9.00	1.00
A 1816	Ammoniated Phosphate	Ionia	'F	0.53	0.20	0.10	0.83	10.15	0.82	9.33	1.02
			'G				1.65			12.00	
A 1817	Big Bonanza	Carson City	'F	1.21	0.21	0.22	1.64	15.45	1.00	14.45	
			'G				0.82			10.00	
A 2398	Favorite Grain Grower	Millington	'F	0.34	0.26	0.21	0.81	12.50	1.48	11.02	
			'G				0.41			10.00	1.00
A 1950*	O. K. Fertilizer	Harbor Beach	'F	0.25	0.15	0.11	0.51	13.00	1.68	11.32	1.12
A 2391	O. K. Fertilizer	Vassar		0.32	0.07	0.12	0.51	14.85	2.72	12.13	0.74
A 2419	O. K. Fertilizer	Adair		0.31	0.07	0.14	0.52	13.60	2.42	11.18	0.50
			Av.	0.29	0.10	0.12	0.51	13.82	2.27	11.55	0.79
			'G				0.41			12.00	
A 1965*	Phosphate with Humus	Ruth	'F	0.35	0.12	0.04	0.51	15.73	1.82	13.91	
A 2390	Phosphate with Humus	Vassar		0.13	0.10	0.23	0.46	14.60	1.92	12.68	
A 2392	Phosphate with Humus	Vassar		0.23	0.07	0.08	0.38	16.13	1.56	14.57	
A 2605*	Phosphate with Humus	Carleton		0.27	0.06	0.08	0.41	13.85	0.86	12.99	
			Av.	0.25	0.09	0.11	0.45	15.08	1.54	12.54	
			'G				0.82			8.00	2.00
A 1813	Potato, Tobacco and Truck Manure	Lake Odessa	'F	0.56	0.18	0.09	0.83	11.50	0.98	10.52	1.70
	Pure Bone Phosphate		'G				1.65			8.00	
			'G				0.82			12.00	1.00
A 1814	Quality Brand	Lake Odessa	'F	0.66	0.16	0.12	0.94	16.80	2.56	14.24	0.99

**Fall Samples.*
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	The Packers Fertilizer Co.—*Con.*										
A 1904*	Quality Brand	Lake Odessa		0.60	0.19	0.14	0.93	15.20	2.68	12.52	1.06
A 2499	Quality Brand	Vassar		0.69	0.15	0.11	0.95	17.00	2.12	14.88	0.70
			Av.	0.65	0.17	0.12	0.94	16.33	2.45	13.88	0.92
			'G	......	......	......	1.25	......	......	9.00	1.00
A 1812	Sweepstakes	Lake Odessa	'F	0.76	0.21	0.27	1.24	12.70	1.34	11.36	0.99
A 1815	Sweepstakes	Ionia		0.93	0.17	0.18	1.28	10.95	0.66	10.29	1.00
A 1818	Sweepstakes	Carson City		0.86	0.19	0.26	1.31	13.00	1.78	11.22	0.91
A 1905*	Sweepstakes	Lake Odessa		0.86	0.24	0.15	1.25	11.35	0.94	10.41	1.07
			Av.	0.85	0.20	0.22	1.27	12.00	1.18	10.82	0.99
	Pulverized Manure Co., Chicago, Ill.										
			'G	......	......	......	1.80	......	......	1.00	1.00
A 2019	Wizard Brand Cattle Manure	Grand Rapids	'F	0.10	0.43	1.34	1.87	1.95	0.18	1.77	1.87
	Wizard Brand Mixed Manure	......	'G	......	......	......	1.80	......	......	1.00	1.00
			'G	......	......	......	1.80	......	......	1.00	1.00
A 2017	Wizard Brand Sheep Manure	Grand Rapids	'F	0.40	0.47	1.25	2.12	2.15	0.16	1.99	1.89
	Queen City Fertilizer Co., Sandusky, Ohio.										
			'G	......	......	......	0.82	......	......	8.00	1.00
A 2476	Special Sugar Beet Grower	Erie	'F	0.56	0.11	0.18	0.86	11.13	1.54	9.59	0.95
	F. S. Royster Guano Co., Baltimore, Md.										
			'G	......	......	......	......	......	......	14.00	......
A 2050	14% Acid Phosphate	Wayland	'F	......	......	......	......	15.70	0.16	15.54	......
A 2101	14% Acid Phosphate	Allegan		......	......	......	......	15.56	0.30	15.26	......
A 2106	14% Acid Phosphate	Otsego		......	......	......	......	16.68	0.24	16.44	......
A 2368	14% Acid Phosphate	Deerfield		......	......	......	......	16.80	0.82	15.98	......
A 2430	14% Acid Phosphate	Richmond		......	......	......	......	16.35	1.16	15.19	......
			Av.	......	......	......	......	16.22	0.54	15.68	......
			'G	......	......	......	......	......	......	16.00	......
A 1852*	High Grade 16% Acid Ph'phate	Nunica	'F	......	......	......	......	18.08	0.58	17.50	......
A 1858*	High Grade 18% Acid Ph'phate	Holland		......	......	......	......	19.10	0.10	19.00	......

A 1890*	High Grade 16% Acid Ph'phate	Conklin		....	....	....	....	16.75	0.48	16.27	....
A 2013	High Grade 16% Acid Ph'phate	Fremont		....	....	....	....	17.75	0.16	17.59	....
A 2020	High Grade 16% Acid Ph'phate	Grand Rapids		....	....	....	....	18.10	0.16	17.94	....
A 2081	High Grade 16% Acid Ph'phate	Benton Harb'r		....	....	....	....	18.75	0.94	17.81	....
A 2099	High Grade 16% Acid Ph'phate	Paw Paw		....	....	....	....	19.25	0.82	18.43	....
A 2100	High Grade 16% Acid Ph'phate	Allegan		....	....	....	....	18.68	0.16	18.52	....
A 2120	High Grade 16% Acid Ph'phate	Niles		....	....	....	....	17.35	0.24	17.11	....
A 2217	High Grade 16% Acid Ph'phate	Plymouth		....	....	....	....	18.60	1.02	17.58	....
A 2344	High Grade 16% Acid Ph'phate	Osseo		....	....	....	....	18.15	1.08	17.07	....
A 2358	High Grade 16% Acid Ph'phate	Adrian		....	....	....	....	17.53	0.18	17.35	....
A 2537*	High Grade 16% Acid Ph'phate	Montgomery		....	....	....	....	19.03	0.28	18.75	....
A 2549*	High Grade 16% Acid Ph'phate	Grand Ledge		....	....	....	....	17.95	0.48	17.47	....
A 2568*	High Grade 16% Acid Ph'phate	Azalia		....	....	....	....	17.25	0.66	16.59	....
			Av.	....	....	....	....	18.15	0.48	17.67	....
			'G	....	....	....	0.82	....	....	8.00	5.00
A 2449	Black Soil Guano	Laingsburg	'F	0.51	0.19	0.28	0.98	10.95	3.14	7.81	5.83
A 2481	Black Soil Guano	Manchester		0.56	0.21	0.25	1.02	12.20	3.08	9.12	4.64
			Av.	0.53	0.20	0.27	1.00	11.58	3.11	8.47	5.24
			'G	....	....	....	0.82	....	....	8.00	1.00
A 1933*	Cuckoo Crop Grower	Shepherd	'F	0.31	0.19	0.25	0.75	9.10	1.24	7.86	0.95
A 1954*	Cuckoo Crop Grower	Ruth		0.33	0.22	0.28	0.83	9.65	1.10	8.55	1.03
A 2102	Cuckoo Crop Grower	Allegan		0.61	0.06	0.21	0.88	11.00	0.46	10.54	1.17
A 2107	Cuckoo Crop Grower	Otsego		0.60	0.06	0.22	0.88	10.00	0.62	9.38	1.03
A 2141	Cuckoo Crop Grower	Decatur		0.30	0.14	0.40	0.84	11.25	1.47	9.78	1.12
A 2215	Cuckoo Crop Grower	Plymouth		0.42	0.08	0.20	0.70	9.10	0.56	8.54	0.99
A 2260	Cuckoo Crop Grower	Erie		0.39	0.09	0.15	0.63	8.22	0.62	7.60	1.03
A 2627*	Cuckoo Crop Grower	Tecumseh		0.25	0.25	0.36	0.86	9.80	0.54	9.26	1.12
A 2638*	Cuckoo Crop Grower	Plymouth		0.59	0.13	0.15	0.87	9.45	0.52	8.93	1.11
			Av.	0.42	0.12	0.26	0.80	9.73	0.79	8.94	1.06
			'G	....	....	....	0.41	....	....	13.00	0.50
A 1853*	Dependo Grain Grower	Nunica	'F	0.21	0.22	0.09	0.52	14.35	0.70	13.65	0.78
A 2150	Dependo Grain Grower	Butternut		0.14	0.09	0.21	0.44	15.20	0.50	14.70	0.52
A 2214	Dependo Grain Grower	Plymouth		0.32	0.14	0.26	0.72	14.15	0.60	13.55	1.08
A 2373	Dependo Grain Grower	Morenci		0.24	0.15	0.30	0.69	14.17	1.38	12.79	0.58
A 2482	Dependo Grain Grower	Manchester		0.23	0.12	0.17	0.52	14.80	1.18	13.62	0.80
A 2569*	Dependo Grain Grower	Azalia		0.16	0.12	0.16	0.44	14.43	0.38	14.05	0.64
A 2602*	Dependo Grain Grower	Carleton		0.14	0.10	0.14	0.38	14.10	0.58	13.52	0.60
			Av.	0.21	0.14	0.18	0.53	14.46	0.77	13.69	0.71
			'G	....	....	....	1.65	....	....	8.00	2.00
A 2122	Dreadnought Fertilizer	Decatur	'F	1.18	0.32	0.40	1.90	9.80	1.88	7.92	1.83
A 2454	Dreadnought Fertilizer	St. Johns		1.17	0.18	0.24	1.59	10.16	2.06	8.10	2.58
A 2625*	Dreadnought Fertilizer	Tecumseh		1.06	0.38	0.38	1.82	9.75	1.32	8.43	1.94
			Av.	1.14	0.29	0.34	1.77	9.91	1.76	8.15	2.12

*Fall Samples.

'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	F. S. Royster Guano Co.—Con.										
			'G	....	....	....	2.06	....	....	12.00	....
A 2431	*Flamingo* Ammo'd Superphos.	Richmond....	'F	1.60	0.43	0.20	2.23	14.45	1.20	13.25	....
			'G	....	....	....	0.41	....	....	8.00	0.50
A 1841*	Half and Half Wheat Fertilizer	Coopersville..	'F	0.36	0.07	0.10	0.53	10.30	0.55	9.75	0.63
A 1903*	*Half and Half Wheat Fertilizer*	*Clarksville....*		0.16	0.12	0.18	0.46	8.45	1.12	7.33	0.51
A 2480	*Half and Half Wheat Fertilizer*	*Manchester...*		0.30	0.15	0.18	0.63	10.93	1.10	9.83	0.60
			Av.	0.27	0.11	0.16	0.54	9.89	0.92	8.97	0.58
			'G	....	....	....	1.65	....	....	10.00	....
A 1801	Penguin Ammo'd Superphos...	Grand Rapids.	'F	0.98	0.35	0.36	1.69	12.35	0.92	11.43	....
A 1902*	Penguin Ammo'd Superphos...	Clarksville....		0.34	0.18	0.19	0.71	13.30	1.04	12.26	....
A 1980	Penguin Ammo'd Superphos...	Clarksville....		0.41	0.18	0.20	0.79	13.80	1.06	12.74	....
A 2303	Penguin Ammo'd Superphos...	Azalia........		1.23	0.39	0.25	1.87	12.50	1.06	11.46	....
A 2375	Penguin Ammo'd Superphos...	Hemlock......		1.11	0.43	0.30	1.84	12.90	2.02	10.88	....
A 2567*	Penguin Ammo'd Superphos...	*Azalia........*		*0.92*	*0.23*	*0.24*	1.39	11.15	*0.74*	10.41	....
			Av.	0.83	0.29	0.26	1.38	12.66	1.14	11.52	....
			'G	....	....	....	....	....	....	10.00	1.00
A 1971*	Phos. and Potash Mixture 10–1.	Imlay City...	'F	....	....	....	....	11.55	0.98	10.57	0.75
A 1975*	Phos. and Potash Mixture 10–1.	Hudsonville...		....	....	....	....	11.05	0.70	10.35	1.12
			Av.	....	....	....	....	11.30	0.84	10.46	0.94
			'G	....	....	....	....	....	....	12.00	1.00
A 1953*	Phos. and Potash Mixture 12–1.	Ruth.........	'F	....	....	....	....	13.70	1.24	12.46	0.99
A 2603*	Phos. and Potash Mixture 12–1.	Carleton......		....	....	....	....	14.10	0.80	13.30	1.04
			Av.	....	....	....	....	13.90	1.02	12.88	1.01
			'G	....	....	....	0.82	....	....	11.00	2.00
A 2163	Special Fish Guano..........	Grand Haven.	'F	0.28	0.09	0.25	0.62	12.50	0.42	12.08	2.06
A 2216	Special Fish Guano..........	Plymouth....		0.71	0.09	0.24	1.04	10.83	0.82	10.01	2.14
A 2624*	Special Fish Guano..........	Tecumseh....		0.49	0.20	0.19	0.88	13.15	1.60	11.55	2.00
			Av.	0.49	0.13	0.23	0.85	12.16	0.95	11.21	2.10
			'G	....	....	....	0.82	....	....	12.00	....
A 1925*	Special Wheat Grower........	Perrinton.....	'F	0.57	0.17	0.17	0.91	13.10	0.58	12.52	....
A 1927*	Special Wheat Grower........	Middleton....		0.57	0.25	0.22	1.04	13.55	1.60	11.95	....
A 2108	Special Wheat Grower........	Otsego.......		0.33	0.21	0.27	0.81	13.60	0.48	13.12	....

A 2343	Special Wheat Grower	Osseo		0.47	0.25	0.22	0.94	14.90	1.10	13.80	....
A 2376	Special Wheat Grower	Hemlock		0.46	0.15	0.33	0.94	14.85	1.30	13.55	....
A 2626*	Special Wheat Grower	Tecumseh		0.50	0.14	0.12	0.76	13.60	1.02	12.58	....
			Av.	0.49	0.20	0.22	0.90	13.93	1.01	12.92	....
			'G				0.82			8.00	2.00
A 1854*	Wheat, Oats and Barley Fer	Nunica	'F	0.52	0.23	0.16	0.91	10.10	0.85	9.15	1.83
A 2448	Wheat, Oats and Barley Fer	Laingsburg		0.49	0.17	0.22	0.88	11.25	1.52	9.73	2.13
			Av.	0.51	0.20	0.19	0.90	10.68	1.19	9.44	1.98
			'G				0.82			8.00	3.00
A 2123	Wonder Worker Guano	Decatur	'F	0.51	0.23	0.31	1.05	11.35	0.94	10.41	3.83
	Smith Agricultural Chemical Co., Columbus, Ohio.		'G	....	....	....	....			14.00	....
A 1781	14% Acid Phosphate	Bad Axe	'F	....	....	....	....	15.60	0.76	14.84	....
A 1881*	14% Acid Phosphate	Fillmore Cen.		....	....	....	....	16.05	1.34	14.71	....
A 1899*	14% Acid Phosphate	Allegan		....	....	....	....	17.70	1.08	16.62	....
A 2087	14% Acid Phosphate	Holland		....	....	....	....	15.65	0.96	14.69	....
A 2049	14% Acid Phosphate	Wayland		....	....	....	....	15.50	1.16	14.34	....
A 2058	14% Acid Phosphate	Nunica		....	....	....	....	16.20	0.84	15.36	....
A 2287	14% Acid Phosphate	Maybee		....	....	....	....	15.25	1.04	14.21	....
			Av.	....	....	....	....	16.00	1.30	14.97	....
			'G	....	....	....	....			16.00	....
A 1879*	16% Acid Phosphate	Fillmore Cen.	'F	....	....	....	....	19.10	1.00	18.10	....
A 1883*	16% Acid Phosphate	Fillmore Cen.		....	....	....	....	18.85	1.10	17.75	....
A 2204	16% Acid Phosphate	Beech		....	....	....	....	17.55	1.04	16.51	....
A 2235	16% Acid Phosphate	Wayne		....	....	....	....	17.85	0.96	16.89	....
			Av.	....	....	....	....	18.34	1.03	17.31	....
			'G				0.80			8.00	1.00
A 1784	Ammo'd Phos. and Potash	Bad Axe	'F	0.26	0.09	0.22	0.57	9.80	1.06	8.74	0.89
A 1864*	Ammo'd Phos. and Potash	Nashville		0.23	0.16	0.39	0.78	11.70	1.06	10.64	0.97
A 2047	Ammo'd Phos. and Potash	Wayland		0.39	0.23	0.24	0.86	11.25	1.30	9.95	0.85
A 2061	Ammo'd Phos. and Potash	Nunica		0.15	0.19	0.27	0.61	7.90	1.24	6.66	0.94
A 2063	Ammo'd Phos. and Potash	Holland		0.27	0.17	0.26	0.70	10.00	1.26	8.74	1.09
A 2205	Ammo'd Phos. and Potash	Beech		0.18	0.30	0.24	0.72	9.65	1.20	8.45	1.00
			Av.	0.25	0.19	0.27	0.71	10.05	1.19	8.86	0.96
			'G				1.60			8.00	1.00
A 2508	Corn, Oats and Wheat Fer	Parma	'F	0.86	0.33	0.30	1.49	10.55	1.04	9.51	1.00
			'G				1.60			12.00	....
A 2437	Crop Producer	Almont	'F	0.93	0.41	0.33	1.67	15.55	2.17	13.38	....

*Fall Samples.
'Abbreviations for Guaranteed and Found. "Duplicate of Sample A 1962.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at	Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	Smith Agricultural Chemical Co.—Con.									
		'G	......	......	......	0.80	......	......	10.00	....
A 2286	General Crop	Maybee 'F	0.31	0.30	0.29	0.90	11.80	1.22	10.58	....
A 2438	*General Crop*	*Almont*	0.17	0.28	0.33	0.78	12.10	1.14	10.96	....
		Av.	0.24	0.29	0.31	0.84	11.95	1.18	10.77	....
		'G	......	......	......	0.80	......	......	15.00	1.00
A 2436	Grain Grower	Almont 'F	0.51	0.16	0.10	0.77	16.35	1.16	15.19	0.88
A 2642*	Grain Grower	Beech	0.30	0.15	0.04	0.49	16.65	1.02	15.63	1.51
		Av.	0.40	0.16	0.07	0.63	16.50	1.09	15.41	1.20
		'G	......	......	......	0.40	......	......	8.00	2.00
A 1783	Potash Formula	Bad Axe 'F	0.07	0.10	0.25	0.42	9.90	0.88	9.02	1.43
A 2046	Potash Formula	Wayland	0.02	0.09	0.28	0.39	11.55	1.82	9.73	1.64
A 2060	Potash Formula	Nunica	0.08	0.10	0.26	0.44	9.50	1.18	8.32	1.49
A 2064	*Potash Formula*	*Holland*	0.04	0.15	0.35	0.54	10.30	1.52	8.78	1.44
A 2207	Potash Formula	Beech	0.24	0.23	0.16	0.63	9.70	1.24	8.46	1.44
A 2236	Potash Formula	Wayne	0.01	0.14	0.30	0.45	11.00	1.18	9.82	1.70
		Av.	0.08	0.14	0.26	0.48	10.32	1.30	9.02	1.52
		'G	......	......	......	0.40	......	......	12.00	....
A 1782	Wheat Maker & Seeding Down	Bad Axe 'F	0.05	0.10	0.25	0.40	13.50	1.02	12.48	....
A 1865*	Wheat Maker & Seeding Down	Nashville	0.10	0.10	0.32	0.42	16.00	3.10	12.90	....
A 1880*	Wheat Maker & Seeding Down	Filmore Cen.	0.04	0.14	0.30	0.48	14.55	2.00	12.55	....
A 2038	Wheat Maker & Seeding Down	Holland	0.05	0.11	0.22	0.38	14.10	1.44	12.66	....
A 2048	*Wheat Maker & Seeding Down*	Wayland	0.22	0.20	0.27	0.69	13.50	1.46	12.04	....
A 2059	Wheat Maker & Seeding Down	Nunica	0.12	0.11	0.24	0.47	14.50	1.56	12.94	....
A 2206	Wheat Maker & Seeding Down	Beech	0.07	0.25	0.16	0.48	13.90	1.30	12.60	....
A 2261	Wheat Maker & Seeding Down	Erie	0.03	0.14	0.24	0.41	14.35	1.46	12.89	....
		Av.	0.08	0.14	0.25	0.47	14.30	1.67	12.63	....
	J. L. & H. Stadler Rendering & Fer. Co., Cleveland, Ohio.									
		'G	......	......	......	0.80	......	......	10.00	....
A 1773	Ammoniated Acid Phosphate	Bad Axe 'F	0.33	0.14	0.32	0.79	10.85	0.96	9.89	....
A 2299	Ammoniated Acid Phosphate	Milan	0.31	0.19	0.27	0.77	11.35	1.06	10.29	....
A 2560*	Ammoniated Acid Phosphate	Milan	0.48	0.16	0.27	0.91	12.25	0.80	11.45	....
		Av.	0.37	0.16	0.29	0.82	11.48	0.94	10.54	....

	Bone Meal and Acid Phos		'G				1.40			10.00	
A 2282	Bone Meal and Acid Phos	Maybee	'F	0.48	0.77	0.39	1.64	19.78	8.50	11.28	
A 2553*	Bone Meal and Acid Phos	Ann Arbor		0.54	0.52	0.68	1.74	20.58	10.63	9.95	
			Av.	0.51	0.65	0.53	1.69	20.18	9.57	10.61	
	General Crop Grower		'G				1.60			10.00	1.00
	Grain Grower		'G				1.60			10.00	
	Harvest King		'G				0.80			9.00	1.00
A 2246	Harvest King	Ida	'F	0.22	0.25	0.32	0.79	10.70	1.16	9.54	1.10
A 2316	Harvest King	Quincy		0.37	0.27	0.50	1.14	10.25	0.90	9.35	1.13
A 2347	Harvest King	Pittsford		0.42	0.18	0.31	0.91	11.65	1.60	10.05	1.13
			Av.	0.34	0.23	0.38	0.95	10.87	1.22	9.65	1.12
	Pure Bone Meal		'G				2.80	20.00			
A 2493	Pure Bone Meal	Dryden	'F	1.07	0.80	1.13	3.00	21.35			
	Vegetable and Grain Grower		'G				0.80			10.00	0.50
A 1775	Vegetable and Grain Grower	Bad Axe	'F	0.36	0.15	0.32	0.83	11.50	1.02	10.48	0.56
A 2247	Vegetable and Grain Grower	Ida		0.23	0.24	0.41	0.88	11.70	1.24	10.46	0.64
A 2294	Vegetable and Grain Grower	Belleville		0.38	0.30	0.33	1.01	11.85	1.18	10.67	0.53
A 2555*	Vegetable and Grain Grower	Ann Arbor		0.37	0.22	0.45	1.04	11.55	1.20	10.35	0.54
A 2616*	Vegetable and Grain Grower	Belleville		0.42	0.20	0.33	0.95	11.90	1.44	10.46	0.50
			Av.	0.35	0.22	0.37	0.94	11.70	1.22	10.48	0.55
	Vegetable Manure		'G				1.20			12.00	
A 2281	Vegetable Manure	Maybee	'F	0.57	0.32	0.49	1.38	13.90	1.80	12.10	
A 2291	Vegetable Manure	Milan		0.73	0.40	0.40	1.53	13.90	1.80	12.10	
A 2348	Vegetable Manure	Pittsford		0.72	0.37	0.47	1.56	13.50	1.96	11.54	
			Av.	0.67	0.36	0.46	1.49	13.76	1.85	11.91	
	Nicholas Swartz, Grand Haven, Mich.										
	Celery Hustler		'G				7.98			3.61	
A 2162	Celery Hustler	Grand Haven	'F	0.01	6.05	2.67	8.73	5.85	1.90	3.95	
	Swift & Co., Chicago, Ill.										
	Bean and Grain Grower		'G				0.82			8.00	3.00
A 2167	Bean and Grain Grower	Muskegon	'F	0.04	0.28	0.38	0.70	12.40	1.06	11.34	2.87
A 2381	Bean and Grain Grower	Adrian		0.51	0.19	0.30	1.00	9.50	1.38	8.12	2.80
A 2383	Bean and Grain Grower	Bay City		0.06	0.40	0.42	0.88	10.00	1.30	8.70	2.19
A 2409	Bean and Grain Grower	Chesaning		0.48	0.17	0.12	0.77	9.15	1.30	7.85	2.01
			Av.	0.27	0.26	0.31	0.84	10.26	1.26	9.00	2.47

*Fall Samples.
'*Abbreviations for Guaranteed and Found.*

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Swift & Co.—Con.										
			'G				0.82			12.00	1.00
A 1752	Bean and Sugar Beet Grower	Saginaw	'F	0.39	0.26	0.18	0.83	14.05	1.36	12.69	1.01
A 1937*	Bean and Sugar Beet Grower	Merrill		0.18	0.27	0.42	0.87	16.20	1.12	15.08	0.75
			Av.	0.29	0.26	0.30	0.85	15.12	1.24	13.88	0.88
			'G				1.65			12.00	2.00
A 2077	Champion Wh't & Corn Grower	Watervliet	'F	0.08	0.97	0.65	1.70	14.15	1.62	12.63	1.50
A 2301	Champion Wh't & Corn Grower	Milan		0.43	0.45	0.33	1.21	15.30	3.06	12.24	2.56
			Av.	0.26	0.71	0.49	1.46	14.73	2.34	12.39	2.03
			'G				1.65			12.00	....
A 2143	Clay Soil Special	Coloma	'F	0.86	0.41	0.29	1.56	13.90	1.04	12.86	....
A 2314	Clay Soil Special	Coldwater		0.47	0.77	0.26	1.50	13.95	2.31	11.64	....
A 2315	Clay Soil Special	Quincy		0.76	0.50	0.41	1.67	13.58	1.69	11.89	....
			Av.	0.70	0.56	0.32	1.58	13.81	1.68	12.13	....
			'G				0.82			8.00	1.00
A 1770	Complete Fertilizer	Minden City	'F	0.33	0.30	0.17	0.80	10.00	1.66	8.34	0.87
A 1785	Complete Fertilizer	Cass City		0.37	0.26	0.16	0.79	11.30	1.04	10.26	0.88
A 1805	Complete Fertilizer	Saranac		0.33	0.29	0.20	0.82	9.75	1.80	7.95	1.08
A 1835*	Complete Fertilizer	Jamestown		0.05	0.28	0.33	0.66	7.25	1.12	6.13	0.91
A 1894*	Complete Fertilizer	Dorr		0.36	0.37	0.17	0.90	11.80	1.86	9.94	0.92
A 2328	Complete Fertilizer	Hillsdale		0.26	0.33	0.23	0.82	10.55	1.94	8.61	1.02
A 2528*	Complete Fertilizer	Hillsdale		0.38	0.38	0.15	0.91	9.88	2.11	7.77	1.06
A 2531*	Complete Fertilizer	Reading		0.33	0.38	0.16	0.87	9.90	1.37	8.57	0.99
A 2552*	Complete Fertilizer	Ann Arbor		0.33	0.36	0.29	0.98	9.25	0.34	8.91	1.17
A 2595*	Complete Fertilizer	Ida		0.30	0.36	0.15	0.81	9.45	1.44	8.01	0.99
			Av.	0.30	0.33	0.21	0.84	9.82	1.47	8.45	0.98
			'G				0.82			12.00	1.00
A 1885*	Diamond "K" Grain Grower	Sparta	'F	0.31	0.39	0.17	0.87	14.80	2.16	12.64	0.98
A 1893*	Diamond "K" Grain Grower	Dorr		0.23	0.40	0.16	0.79	14.03	3.51	10.52	1.11
A 2111	Diamond "K" Grain Grower	Plainwell		0.28	0.26	0.26	0.80	13.90	1.27	12.63	1.02
A 2141	Diamond "K" Grain Grower	Benton Harbor		0.41	0.29	0.16	0.86	13.90	1.36	12.54	1.01
A 2300	Diamond "K" Grain Grower	Milan		0.39	0.33	0.26	0.98	14.45	1.44	13.01	1.34
A 2611*	Diamond "K" Grain Grower	Waltz		0.26	0.34	0.15	0.75	12.80	1.70	11.10	1.02
A 2617*	Diamond "K" Grain Grower	Belleville		0.34	0.34	0.16	0.84	14.85	1.68	13.17	0.98
A 2623*	Diamond "K" Grain Grower	Dundee		0.24	0.37	0.19	0.80	13.95	1.92	12.03	1.05
			Av.	0.31	0.34	0.19	0.84	14.09	1.88	12.21	1.06

	Diamond "S" Phosphate		'G							10.00	
			'G				3.29			8.00	3.00
A 2385	Diamond "U" Fruit and Vegetable *Grower*	Bay City	'F	0.24	1.96	0.86	3.06	9.85	1.44	8.41	3.09
			'G							14.00	
A 1947*	Garden City Phosphate	Bad Axe	'F					17.65	1.14	16.51	
A 1956*	Garden City Phosphate	Tyre						16.20	1.28	14.92	
A 2169	Garden City Phosphate	Muskegon						17.60	2.76	14.84	
A 2457	Garden City Phosphate	Eden						16.84	1.14	15.70	
			Av.					17.07	1.58	15.49	
			'G				2.06	27.00			
A 2068	Ground Beef Bone Fertilizer	Fennville	'F	0.26	1.14	0.65	2.05	26.95			
A 2076	Ground Beef Bone Fertilizer	Watervliet		0.37	1.21	0.40	1.98	27.00			
A 2084	Ground Beef Bone Fertilizer	Glendora		0.40	1.19	0.63	2.22	27.20			
A 2166	Ground Beef Bone Fertilizer	Muskegon		0.29	1.22	0.69	2.12	27.60			
A 2384	Ground Beef Bone Fertilizer	Bay City		0.37	0.94	0.49	1.80	24.67			
A 2551	Ground Beef Bone Fertilizer	Ann Arbor		0.37	0.92	0.66	1.95	27.10			
			Av.	0.34	[illegible]	0.58	2.02	26.75			
			'G							16.00	
A 1769	High Grade Acid Phosphate	Minden City	'F					17.80	1.16	16.64	
A 2067	High Grade Acid Phosphate	Fennville						17.95	1.14	16.81	
A 2105	High Grade Acid Phosphate	Allegan						18.90	2.48	16.42	
A 2145	High Grade Acid Phosphate	Coloma						18.19	1.30	16.89	
A 2313	High Grade Acid Phosphate	Coldwater						17.93	1.82	16.11	
A 3214*	High Grade Acid Phosphate	Fulton						19.10	1.34	17.76	
A 2630*	High Grade Acid Phosphate	Ypsilanti						18.35	1.42	16.93	
			Av.					18.32	1.53	16.79	
			'G				1.65			1.00	1.50
A 2062	Pulverized Sheep Manure	Grand Rapids	'F	0.16	0.43	1.22	1.81	1.55	0.18	1.37	2.80
A 2112	Pulverized Sheep Manure	Kalamazoo		0.11	0.45	1.27	1.83	2.00	0.26	1.74	3.09
A 2386	Pulverized Sheep Manure	Bay City		0.26	0.45	1.24	1.95	1.40	0.22	1.18	2.15
			Av.	0.18	0.44	1.24	1.86	1.65	0.22	1.43	2.68
	Special Superphosphate		'G				1.65			8.00	1.00
			'G				1.65			8.00	2.00
A 2168	Superphosphate	Muskegon		0.01	0.77	0.36	1.14	10.95	0.96	9.99	1.42
A 2382	Superphosphate	Bay City		0.09	0.69	0.46	1.24	11.55	2.64	8.91	1.14
A 2444	Superphosphate	Lapeer		0.89	0.44	0.43	1.76	11.15	1.70	9.45	1.62
A 2456	Superphosphate	Eden		0.70	0.37	0.56	1.63	10.40	1.30	9.10	1.64
			Av.	0.12	0.57	0.15	1.44	11.01	1.65	9.36	1.46

***Fall Samples.**
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen.				Phosphoric Acid.			Potash.
				As Soluble.	As Active Insoluble Organic.	As Inactive Insoluble Organic.	Total.	Total.	Insoluble.	Available.	Total.
	Swift & Company—Cont.										
			'G				0.82			12.00	
A 1771	Tankage and Bone Phosphate	Minden City	'F	0.41	0.28	0.19	0.88	13.85	1.46	12.39	
A 1837*	Tankage and Bone Phosphate	Jamestown		0.23	0.40	0.10	0.73	13.68	3.43	10.25	
A 1861*	Tankage and Bone Phosphate	Caledonia		0.44	0.35	0.07	0.86	13.88	2.16	11.72	
A 1883*	Tankage and Bone Phosphate	Hamilton		0.40	0.29	0.22	0.91	14.40	1.28	13.12	
A 2045	Tankage and Bone Phosphate	Ross		0.33	0.31	0.23	0.87	14.10	1.22	12.88	
A 2069	Tankage and Bone Phosphate	Fennville		0.38	0.28	0.18	0.84	14.55	2.06	12.49	
A 2092	Tankage and Bone Phosphate	Three Oaks		0.36	0.29	0.18	0.83	14.40	1.10	13.30	
A 2104	Tankage and Bone Phosphate	Allegan		0.40	0.28	0.18	0.86	14.40	1.74	12.66	
A 2213	Tankage and Bone Phosphate	Newberg		0.36	0.27	0.20	0.83	14.95	1.64	13.31	
A 2515*	Tankage and Bone Phosphate	Fulton		0.33	0.29	0.08	0.70	14.55	1.64	12.91	
A 2527*	Tankage and Bone Phosphate	Hillsdale		0.55	0.26	0.09	0.90	14.30	1.90	12.40	
			Av.	0.38	0.30	0.16	0.84	14.27	1.78	12.49	
	Truck Fertilizer		'G				2.47			8.00	1.00
			'G				1.65			10.00	
A 1863*	Wheat and Rye Special 2-10	Caledonia	'F	0.75	0.46	0.27	1.48	12.00	1.86	10.14	
A 1970*	Wheat and Rye Special 2-10	North Branch		0.69	0.39	0.22	1.30	12.00	1.64	10.36	
A 2612*	Wheat and Rye Special 2-10	Waltz		0.69	0.35	0.28	1.32	11.43	1.48	9.95	
			Av.	0.71	0.40	0.26	1.37	11.81	1.66	10.15	
			'G				1.23	20.00			
A 2532*	1½-20 Bone Meal	Reading	'F	0.10	0.38	1.06	1.54	20.00			
A 2618*	1½-20 Bone Meal	Belleville		0.18	0.78	0.42	1.38	20.60			
A 2622*	1½-20 Bone Meal	Dundee		0.24	0.53	0.45	1.22	21.70			
			Av.	0.17	0.56	0.65	1.38	20.77			
			'G				1.85	29.00			
A 1836*	2¼-29 Bone Meal	Jamestown	'F	0.35	1.14	0.50	1.99	29.20			
A 1862*	2¼-29 Bone Meal	Caledonia		0.37	1.12	0.50	1.99	30.50			
			Av.	0.36	1.13	0.50	1.99	29.85			
			'G				0.82			8.00	2.00
A 1892*	1-8-2 Fertilizer	Dorr	'F	0.35	0.29	0.22	0.86	10.40	1.98	8.42	1.67
A 1906*	1-8-2 Fertilizer	Lake Odessa		0.38	0.25	0.28	0.91	11.33	2.62	8.71	1.64
A 1936*	1-8-2 Fertilizer	Merrill		0.46	0.15	0.20	0.81	10.55	1.46	9.09	1.71
A 2168	1-8-2 Fertilizer	Middleton		0.39	0.19	0.22	0.80	10.10	1.20	8.90	2.19
A 2198	1-8-2 Fertilizer	Ithaca		0.42	0.20	0.19	0.81	10.85	1.90	8.95	1.93

A 2455*	1-8-2 Fertilizer	Ann Arbor		0.36	0.28	0.22	0.86	9.80	2.31	7.49	1.73
			Av.	0.39	0.22	0.22	0.83	10.51	1.91	8.60	1.81
			'G	...	...	...	0.82	...	...	8.00	5.00
A 2469	1-8-5 Fertilizer	Birch Run	'F	0.27	0.31	0.42	1.00	10.15	0.94	9.21	5.32
			'G	...	...	...	0.82	...	...	10.00	...
A 1946*	1-10-0 Fertilizer	Bad Axe	'F	0.22	0.23	0.21	0.66	11.05	0.94	10.11	...
A 1973*	1-10-0 Fertilizer	Capac		0.42	0.26	0.18	0.86	11.50	0.78	10.72	...
A 2396	1-10-0 Fertilizer	Millington		0.32	0.36	0.20	0.88	12.05	1.06	10.99	...
			Av.	0.32	0.28	0.20	0.80	11.54	0.93	10.61	...
			'G	...	...	...	1.65	...	...	10.00	...
A 2110	2-10-0 Fertilizer	Plainwell	'F	0.60	0.36	0.32	1.28	11.70	1.68	10.02	...
			'G	...	...	...	4.12	...	...	8.90	...
A 2144	5-8-0 Fertilizer	Coloma	'F	1.86	0.84	0.98	3.68	12.20	3.10	9.10	...
	United Chemical & Organic Products Co., Chicago, Ill.										
	Calumet Brands.										
			'G	...	...	...	...	...	...	14.00	...
A 2252	Acid Phosphate	Petersburg	'F	...	...	...	...	18.35	1.96	16.39	...
A 2360	Acid Phosphate	Adrian		...	...	...	...	19.65	4.96	14.69	...
A 2367	Acid Phosphate	Deerfield		...	...	...	...	20.55	6.26	14.29	...
A 2587*	Acid Phosphate	Petersburg		...	...	...	...	18.25	1.96	16.29	...
			Av.	...	...	...	...	19.20	3.79	15.41	...
			'G	...	...	...	0.80	...	...	10.00	0.50
A 2492	Beeo Fertilizer	Dryden	'F	0.31	0.17	0.31	0.79	13.90	3.72	10.18	0.63
			'G	...	...	...	0.40	...	...	10.00	1.00
A 1792	Bone Phos. and Potash Mixture	Imlay City	'F	0.22	0.25	0.29	0.76	14.80	2.64	12.16	0.53
A 2007	Bone Phos. and Potash Mixture	Jamestown		0.03	0.24	0.28	0.55	14.92	3.10	11.82	0.49
A 2119	Bone Phos. and Potash Mixture	Niles		0.21	0.21	0.31	0.73	14.35	2.53	11.82	0.68
A 2254	Bone Phos. and Potash Mixture	Petersburg		0.23	0.33	0.30	0.86	15.05	4.04	11.01	0.64
A 2346	Bone Phos. and Potash Mixture	Pittsford		0.23	0.27	0.24	0.74	14.40	2.80	11.60	1.00
A 2588*	Bone Phos. and Potash Mixture	Petersburg		0.29	0.24	0.35	0.88	15.75	5.72	10.03	0.71
			Av.	0.20	0.25	0.30	0.75	14.88	3.47	11.41	0.68
			'G	...	...	...	0.60	...	...	8.00	...
A 1790	Coburn Special	Imlay City	'F	0.13	0.19	0.47	0.79	11.80	2.60	9.20	...
			'G	...	...	...	0.60	...	...	8.50	0.50
A 2253	*Coburn Special and Potash*	Petersburg	'F	0.21	0.30	0.22	0.73	12.50	1.90	10.60	0.57

***Fall Samples.**
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	United Chemical & Organic Products Co.—Con.										
A 2366	Coburn Special and Potash....	Deerfield.....		0.28	0.25	0.33	0.86	13.00	3.04	10.96	0.59
A 2586*	Coburn Special and Potash....	Petersburg....		0.19	0.18	0.37	0.74	12.10	2.02	10.08	0.51
			Av.	0.23	0.24	0.31	0.78	12.54	1.99	10.55	0.56
			'G				0.80			10.00	
A 2008	Corn and Wheat Grower......	Jamestown...	'F	0.44	0.30	0.12	0.86	15.30	3.38	11.92	
A 2128	Corn and Wheat Grower......	Lawton......		0.28	0.27	0.32	0.87	15.10	2.44	12.66	
A 2394	Corn and Wheat Grower......	Millington....		0.21	0.36	0.41	0.98	14.10	2.60	11.50	
			Av.	0.31	0.31	0.28	0.90	14.84	2.81	12.03	
			'G				0.80			10.00	0.50
A 1791	Hummer Grain Grower........	Imlay City...	'F	0.29	0.29	0.22	0.80	14.05	2.60	11.45	0.67
A 2009	Hummer Grain Grower........	Jamestown...		0.24	0.23	0.36	0.83	13.60	2.00	11.60	0.47
A 2345	Hummer Grain Grower........	Pittsford.....		0.23	0.25	0.22	0.70	14.80	2.86	11.94	1.02
			Av.	0.25	0.26	0.27	0.78	14.15	2.49	11.66	0.72
			'G				0.82	29.77			
A 2127	Special Pure Bone Meal.......	Lawton......	'F	0.19	0.56	0.19	0.94	33.03			
A 2359	Special Pure Bone Meal.......	Adrian.......		0.23	0.49	0.19	0.91	31.25			
			Av.	0.21	0.53	0.19	0.93	32.14			
	Virginia-Carolina Chemical Co., Cincinnati, Ohio.										
			'G							16.00	
A 2414	16% Acid Phosphate..........	Erie..........	'F					21.25	3.36	17.89	
A 2558*	16% Acid Phosphate..........	Milan.........						20.60	1.06	19.54	
A 2574*	16% Acid Phosphate..........	Adrian.......						17.85	1.40	16.45	
			Av.					19.90	1.94	17.96	
			'G							20.00	
A 2302	20% Acid Phosphate..........	Milan.........	'F					22.90	1.04	21.86	
			'G				0.82			10.00	
A 2559*	Bone Meal and Phosphate.....	Milan.........	'F	0.03	0.67	0.24	0.94	23.25	12.82	10.43	
A 2633*	Bone Meal and Phosphate.....	Manchester...		0.29	0.37	0.27	0.93	23.80	9.42	14.38	
			Av.	0.16	0.52	0.26	0.94	23.53	11.12	12.41	

	Champion Corn & Wh. Grower		'G				0.82			8.00	2.00
2635*		Manchester	'F	0.37	0.29	0.34	1.00	9.70	0.72	8.98	2.27
	Complete Fertilizer		'G				1.65			8.00	2.00
	Complete Manure		'G				0.82			8.00	1.00
A 2413	Complete Manure	Erie	'F	0.40	0.24	0.31	0.95	10.80	1.50	9.30	1.15
A 2479	Complete Manure	Urania		0.47	0.30	0.24	1.01	17.32	8.24	9.08	1.04
A 2556*	Complete Manure	Milan		0.16	0.13	0.22	0.51	6.14	0.36	5.78	0.64
			Av.	0.34	0.22	0.26	0.82	11.42	3.37	8.05	0.94
	Farmers' Friend		'G				0.82			8.00	3.00
	Red Cross 14%		'G							14.00	
A 2415	Red Cross 14%	Erie	'F					18.68	3.62	15.06	
A 2557*	Red Cross 14%	Milan						18.75	1.86	16.89	
			Av.					18.72	2.74	15.98	
	Rescue Fertilizer		'G				1.65			11.00	
A 2478	Rescue Fertilizer	Urania	'F	0.94	0.39	0.52	1.85	16.45	3.60	12.85	
	Richmus Fertilizer		'G				0.41			12.00	
A 2412	Richmus Fertilizer	Erie	'F	0.22	0.11	0.12	0.45	16.50	1.72	14.78	
A 2610*	Richmus Fertilizer	Waltz		0.01	0.15	0.33	0.49	13.45	0.76	12.69	
			Av.	0.11	0.13	0.23	0.47	14.98	1.24	13.74	
	Sure Grain Producer		'G				0.82			13.00	
A 2477	Sure Grain Producer	Urania	'F	0.40	0.42	0.19	1.01	19.45	3.60	15.85	
A 2485	Sure Grain Producer	Clinton		0.49	0.12	0.22	0.83	17.65	1.19	16.41	
A 2634*	Sure Grain Producer	Manchester		0.34	0.29	0.38	1.01	14.50	0.36	14.14	
			Av.	0.41	0.28	0.26	0.95	17.20	1.72	15.48	
	Rasin-Monumental Brands 14 % Acid Phosphate		'G							14.00	
	16% Acid Phosphate		'G							16.00	
A 1874*	16% Acid Phosphate	Coopersville	'F					19.50	0.80	18.70	
A 2309	16% Acid Phosphate	Batavia						18.92	1.12	17.80	
A 2475	16% Acid Phosphate	Lansing						20.55	1.76	18.70	
			Av.					19.66	1.23	18.43	
	20% Acid Phosphate		'G							20.00	
	Big Giant Phosphate		'G				0.82			8.00	3.00
	Farmers' Success		'G				0.82			8.00	1.00
A 2473	Farmers' Success	Lansing	'F	0.23	0.27	0.34	0.84	9.50	0.80	8.70	1.46

*Fall Samples.
'Abbreviations for Guaranteed and Found.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1918, EXPRESSED IN PARTS IN ONE HUNDRED—Continued

Laboratory No.	Manufacturer and Trade Name.	Sampled at		Nitrogen. As Soluble.	Nitrogen. As Active Insoluble Organic.	Nitrogen. As Inactive Insoluble Organic.	Nitrogen. Total.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash. Total.
	Rasin-Monumental Brands —Con.										
	Fenhumus Fertilizer..........	....	'G	....	....	....	0.41	....	....	12.00	....
2307	General Favorite............	Batavia......	'G	....	....	....	1.65	....	....	8.00	2.00
			'F	1.48	0.02	0.17	1.67	11.15	1.14	10.01	2.20
2474	Grain Fertilizer..............	Lansing......	'G	....	....	....	0.82	....	....	13.00	....
			'F	0.31	0.30	0.29	0.90	16.65	1.74	14.91	....
	Phosphate and Bone Meal.....	....	'G	....	....	....	0.82	....	....	10.00	....$MM
	Reliable Wheat & Corn Fer....		'G	....	....	....	0.82	....	....	8.00	2.00
2308	Reliable Wheat & Corn Fer....	Batavia......	'F	0.30	0.29	0.24	0.83	10.25	0.96	9.29	1.68
2472	Reliable Wheat & Corn Fer....	Lansing......	'F	0.17	0.34	0.32	0.83	10.15	1.02	9.13	1.35
			Av.	0.24	0.31	0.28	0.83	10.20	0.99	9.21	1.52
1875*	Royal Grain Grower.........	Coopersville..	'G	....	....	....	....	....	....	12.00	2.00
			'F	....	....	....	....	14.70	1.00	13.70	2.00
	Special Plant Food..........	....	'G	....	....	....	1.65	....	....	11.00	....
	Wolcott Packing Co., Flint, Mich.										
2470	Blood and Bone..............	Flint.........	'G	....	....	....	4.00	....	....	8.00	....
			'F	1.78	2.05	0.76	4.59	20.05	5.28	14.77	....
	Tankage......................	....	'G	....	....	....	1.25	24.00	....		....
	The Wuichet Fertilizer Co., Dayton, Ohio.										
	EE Ammonia Special.........		'G	....	....	....	0.80	....	....	10.00	....
1802	EE Ammonia Special.........	Lowell.......	'F	0.20	0.35	0.35	0.90	13.80	2.16	11.64	....
2153	EE Ammonia Special.........	Sparta.......		0.23	0.45	0.44	1.12	14.42	1.92	12.50	....
2466	EE Ammonia Special.........	Swartz Creek.		0.25	0.42	0.41	1.08	15.43	2.14	13.29	....
2468	EE Ammonia Special.........	Birch Run....		0.32	0.49	0.54	1.35	15.75	3.23	12.52	....
			Av.	0.25	0.43	0.43	1.11	12.47	2.38	12.49	....
	16% Phosphate...............		'G	....	....	....	....	....	....	16.00	....
2378	16% Phosphate...............	Hemlock.....	'F	....	....	....	....	18.68	1.50	17.18	....
2545*	16% Phosphate...............	Montgomery..		....	....	....	....	18.05	0.18	17.87	....

	EE Raw Bone and Phosphate		'G	....	....	....	1.60	....	....	8.00	....
			'G	....	....	....	0.40	....	....	11.00	....
A 1803	EE Ruby Fertilizer	Lowell	'F	0.09	0.23	0.14	0.46	12.90	1.20	11.70	....
A 1910*	EE Ruby Fertilizer	Woodbury		0.20	0.22	0.13	0.55	14.50	0.50	14.00	....
A 1926*	EE Ruby Fertilizer	Middleton		0.17	0.22	0.09	0.48	15.35	1.72	13.63	....
A 2154	EE Ruby Fertilizer	Sparta		0.14	0.20	0.15	0.49	13.45	1.56	11.89	....
A 2178	EE Ruby Fertilizer	Mulliken		0.19	0.24	0.17	0.60	13.00	0.46	12.54	....
A 2182	EE Ruby Fertilizer	Middleton		0.14	0.22	0.13	0.49	13.95	1.42	12.53	....
A 2377	EE Ruby Fertilizer	Hemlock		0.11	0.24	0.15	0.51	13.55	1.38	12.17	....
A 2408	EE Ruby Fertilizer	Chesaning		0.10	0.22	0.20	0.52	13.41	1.26	12.15	....
A 2544*	EE Ruby Fertilizer	Montgomery		0.12	0.27	0.13	0.52	15.30	2.02	13.28	....
			Av.	0.14	0.23	0.14	0.51	13.93	1.28	12.65	....
			'G	....	....	....	0.80	....	....	8.00	1.00
A 1919*	EE Spot Cash	Fowler	'F	0.20	0.23	0.38	0.81	13.15	3.56	9.59	1.11
A 2152	EE Spot Cash	Sparta		0.34	0.36	0.34	1.04	14.35	3.26	11.09	0.95
A 2370	EE Spot Cash	Hemlock		0.31	0.36	0.33	1.00	12.95	3.18	9.77	1.05
A 2446	EE Spot Cash	Perry		0.25	0.36	0.37	0.98	14.95	4.34	10.61	0.98
A 2465	EE Spot Cash	Swartz Creek		0.29	0.36	0.33	0.98	14.92	4.60	10.32	1.00
			Av.	0.28	0.33	0.35	0.96	14.06	3.79	10.27	1.02

***Fall Samples.**
'Abbreviations for Guaranteed and Found.

SOME INFORMATION AND SUGGESTIONS CONCERNING THE USE OF PHOSPHORUS.

Bulletin No. 284

M. M. McCool, G. M. Grantham, C. E. Millar.

INTRODUCTION.

Phosphorus is known to have been used in Europe as early as 1653 for soil improvement. In this country its benefits were early recognized and the amount applied to the soil has steadily increased until it is made use of with safe margins of profit in all the older agricultural regions. Moreover, it has been found to be profitable on some of the more recently developed lands. Of course, there are several explanations for its wide popularity.

This report discusses terms used, forms in which phosphorus may be purchased; its effect on crop growth and on the soil; the time, manner and amount to apply; removal of phosphorus from Michigan farms; the amount of commercial phosphate required to make good this loss; soil composition; and some results obtained from the judicious use of phosphorus.

Terms Used. It is rather unfortunate, since it confuses some, that several terms are used in referring to this valuable element of plant-food. These are used somewhat loosely, but strictly speaking they convey a definite meaning to the chemist or to those who have some knowledge of chemistry. It is sometimes spoken of as phosphorus, as phosphoric acid, and as phosphate.

When it is stated, for example, that a substance contains 4.4 per cent of phosphorus it means the same thing as when it is said that it contains 10 per cent phosphoric acid. Thus, in order to express the phosphorus content of a substance as an equivalent amount of phosphoric acid it must be multiplied by 2.3 and in order to express the phosphoric acid content of a substance as an equivalent amount of phosphorus it must be multiplied by .44. Many farmers use the term phosphate in a very general or broad sense, all kinds of fertilizers, those containing only phosphorus as well as mixed goods, being spoken of as phosphates. The term phosphate as used in this report refers to one or all of the three carriers spoken of below.

Carriers of Phosphorus. There are three phosphates or carriers of phosphorus, aside from mixed goods, which are worthy of mention so far as Michigan agriculture is concerned, namely: raw rock phosphate, bone meal, and acid phosphate.

Raw rock phosphate or "floats" is found in natural deposits and has been extensively mined in South Carolina, Florida and Tennessee. Other deposits are also known to exist in Alabama, North Carolina, Nevada, Pennsylvania, Arkansas, Idaho, Wyoming, Utah and Montana. The phosphorus occurring in this carrier is slow acting when applied to the soil and consequently it should be added in large quantities.

Finely ground bone or bone meal is obtained from packing and other slaughter houses and is somewhat more active in its effect on the crops than raw rock phosphate and therefore the applications consist of somewhat smaller amounts.

Acid phosphate, the most extensively used in Michigan, is derived chiefly from raw rock phosphate and is manufactured by adding about one ton of strong sulphuric acid to one ton of the floats. As a result of this mixture the acid is neutralized and the phosphorus is converted into a much more active or available condition. Bone meal may be treated in a similar manner. The product obtained is commonly spoken of as acidulated bone, or soluble bone and the phosphorus exists in the same form as it does when floats are treated with the acid.

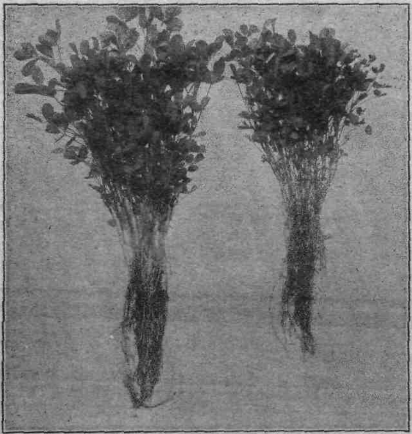


Figure 1.—Alfalfa is an exacting crop requiring an abundance of lime and other elements of plant-food. The plants on the right are typical of those growing on limed sandy soil, those on the left were taken from the same soil to which had been applied lime and 300 pounds of acid phosphate per acre. Ingham County sandy soil.

Effect of Phosphorus on Crops. An application of phosphorus in suitable quantities to soils deficient in this plant-food element proves to be beneficial in several respects. It is known to increase tremendously the root production of plants, causing them to strike more deeply into the soil as well as to be more numerous in the surface soil. This has been reported to be of value during periods of drouth, enabling the plant to draw upon larger areas of soil for water and elements of plant-food. It results in greater leaf and stem development, and aids materially in

grain or seed formation and speeds up the maturity or shortens the length of the growing season. It may also raise the feeding value of the crops produced. It is maintained by agricultural writers that the most nutritious pastures in England and the best dairy pastures in France are those *richest in phosphorus.*

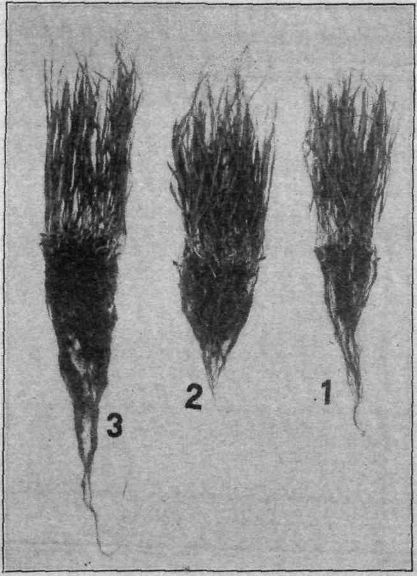


Figure 2.—The root development of plants is increased by available plant-food elements. No. 1 wheat grown in untreated soil. No. 2 wheat grown in soil receiving green manure. No. 3 wheat grown in soil treated with acid phosphate.

Effect of Phosphorus Carriers on Soils. Phosphate fertilizers do not injure the soil. Some farmers are reluctant to use these carriers of phosphorus because of the impression that they may prove valuable for a time and later lose their efficiency leaving the soil in a less productive state than formerly, markedly increasing the need for lime, decreasing or "burning out" the organic matter and injuring the tilth of the soil. These are misconceptions as long and carefully conducted field tests, notably at the Rothamsted Agricultural Experiment Station, England, and at the Pennsylvania, Massachusetts, Ohio and Illinois Experiment

Stations, have shown conclusively that the continued use of phosphorus on the land is a safe, sane and business like operation as measured by the increase in yield of the crops grown and the effect upon the soil. The lime content of the soil is not markedly changed by the use of either acid phosphate or bone meal. Inasmuch as raw rock phosphate or "floats" sometimes contains appreciable quantities of carbonate of lime, its use results in the lessening of the so-called acid or sour condition. Our investigations on the solubility of soils that have been treated with certain phosphates indicate that their presence decreases the rate of solubility of some of the mineral constituents and thus reduces the losses due to leaching.

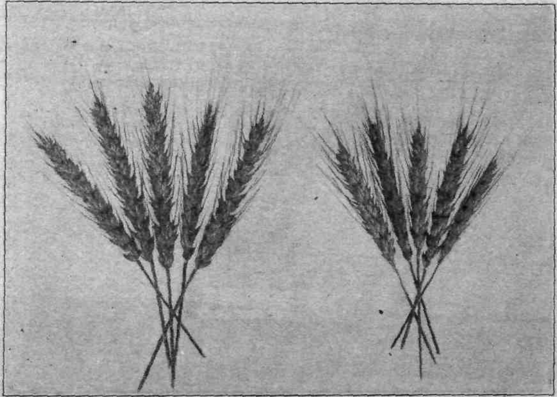


Figure 3.—Wheat responds to phosphorus. On the right typical heads of wheat grown on untreated soil, on the left heads of wheat grown on the same soil treated with 200 pounds of acid phosphate.

Now with respect to the effect upon the tilth of the soil it is doubtless true that as a result of their application there is a tendency toward an improvement of the soil on account of the increase of the vegetable matter, if care is taken to conserve it. Of course, if rotation of crops and proper tillage are not practiced and the manure and crop residues not returned to the land the tilth of the fine textured soils will be impaired but not necessarily to greater extent with the fertilizer than without it.

Amount to Apply. The amount of phosphate fertilizer to apply to the soil depends upon the carrier and the kind of crops grown and the nature of the soil. The law of diminishing returns should always be considered, that is to say a small application of a phosphate fertilizer results in a

greater percentage of increase of crop than does a larger one. This means, of course, that there is a limit to the profitable use of them, inasmuch as the cost of the fertilizer rises in direct proportion to the amount used; the rate of increase in the yield does not do so after a certain point is reached and, finally the value of the product becomes less than the cost of the fertilizer. Naturally those who cannot afford to take chances on the weather, fluctuation in prices, and other conditions should be somewhat more conservative in their use than others. The law of diminishing returns with respect to the use of fertilizers is illustrated in figure 4.

Where rock phosphate, the slow acting form, is utilized as a source of phosphorus, the applications range in amount from 1000 to 2000 pounds per acre, the slow availability being made up for in quantity.

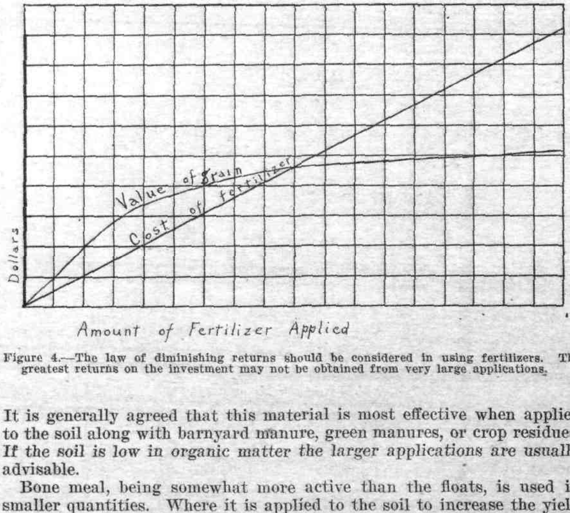


Figure 4.—The law of diminishing returns should be considered in using fertilizers. The greatest returns on the investment may not be obtained from very large applications.

It is generally agreed that this material is most effective when applied to the soil along with barnyard manure, green manures, or crop residues. If the soil is low in organic matter the larger applications are usually advisable.

Bone meal, being somewhat more active than the floats, is used in smaller quantities. Where it is applied to the soil to increase the yield of small grains and grasses, 300 to 600 pound applications per acre are made and 1000 or more pounds for the larger cash crops. This form is not extensively used in Michigan.

The active form or acid phosphate is applied to the small grains and grasses in amounts ranging from 80 to 300 pounds per acre, the average being about 200 pounds; for potatoes, beets and tomatoes, 300 to 500 pounds are usually considered ample while somewhat larger amounts are sometimes utilized for the production of cabbage, onions and celery. It is generally considered to be inadvisable to mix acid phosphate with

either caustic lime or wood ashes and if mixed with nitrate of soda the mixture should be applied immediately.

Where to Apply. It is usually advisable to fertilize the rotation. Phosphates are fixed or held by the soil until utilized by growing plants, although when acid phosphate is applied to light sands it may be washed downward to some extent. This means that crops following in the rotation are benefited by phosphorus left by previous crops. It is generally considered that about two-thirds the cost of the application of acid phosphate should be charged to the first crop and the remainder to those that follow in the rotation. In case of the floats these figures do not apply and it is usually the practice to add them to the clover or other sod before plowing and repeat the application in from four to six years, depending upon the size of the application and the crops grown. It is advisable to apply the bone meal or acid phosphate to the grain crops in the rotation as illustrated by figures 6 and 7. In several sections it is becoming more

Figure 5.—Oats growing on Van Buren Co. sandy soil. On the left 1000 pounds of rock phosphate per acre were applied to corn before the oats. On the right 2000 pounds were added. It pays to use the rock phosphate freely.

and more difficult to obtain suitable stands of clover with small grains, as a result proper rotation of crops becomes difficult. It is doubtless true that the lack of both lime and phosphorus in the soil accounts in a large measure for this undesirable condition and judicious applications of these result favorably as illustrated by figure 8.

How to Apply. There are several methods of applying these fertilizers. Raw rock phosphate is applied by means of a lime and phosphate distributor, fertilizer drill, or with the manure spreader when the manure is applied to the soil. Bone meal may be broad-casted and incorporated with the soil when the seed bed is prepared, distributed by means of a fertilizer distributor or attachment to the grain drill.

A FOUR YEAR CASH CROP ROTATION.

Figure 6.—Owing to the residuary effects of phosphates the rotation should be fertilized. A four year rotation for the finer textured soils showing the places to apply phosphates to best advantage.

A THREE YEAR ROTATION FOR SANDY SOIL

Figure 7.—Rotation for sandy soil showing where to apply phosphate fertilizers.

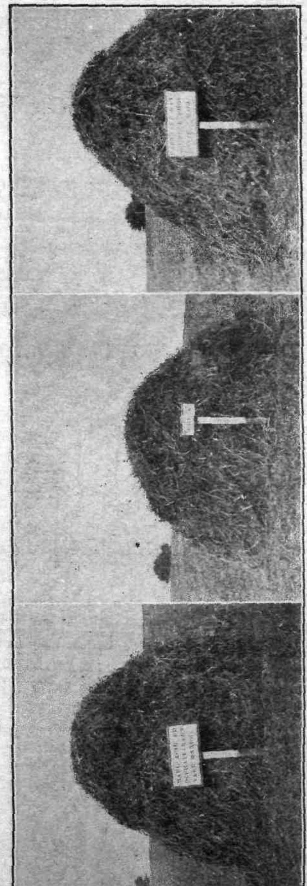


Figure 8.—The use of *phosphates* and marl is proving very beneficial to clover on many *Michigan* soils.

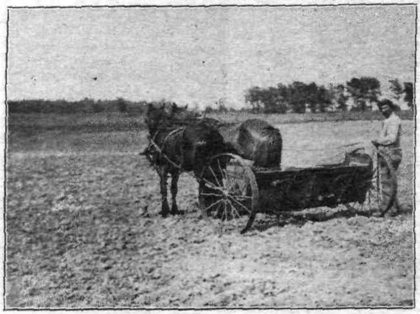


Figure 9.—Lime, rock phosphate or other fertilizers may be applied by means of a combination sower.

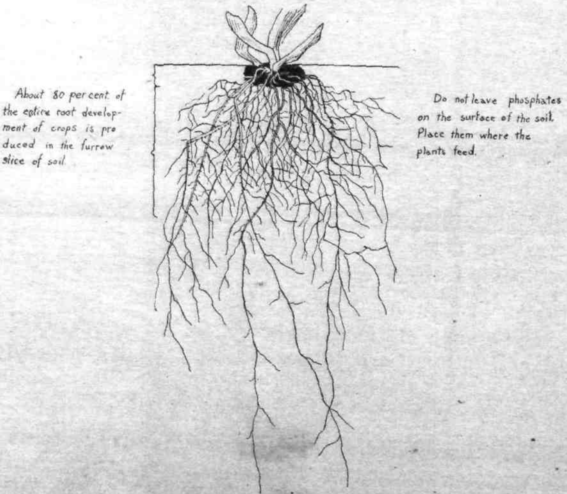
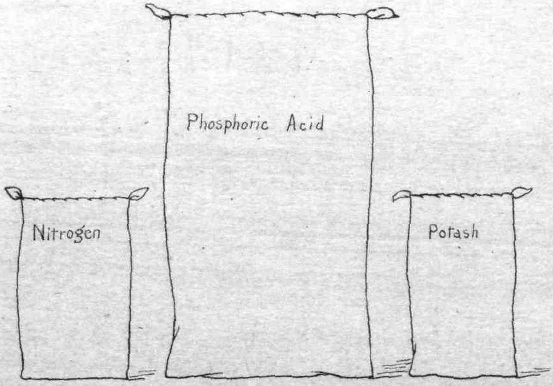


Figure 10.—Except when used in top dressing permanent meadows and pastures phosphatic fertilizers should be incorporated with the soil.

Acid phosphate is sometimes applied in the hill for corn or potatoes that is where small applications are made. This is not generally advisable inasmuch as the crops that follow do not receive much benefit from the residues. Some broadcast it by hand after the land is plowed and work it into the soil when the seed bed is being prepared. The majority of farmers, however, apply it by means of the fertilizer drill or attachment on the grain drill. In some cases it is sprinkled over manure in the spreader and applied along with it.

The fact should not be overlooked that the efficiency of these fertilizers is dependent upon their thorough incorporation with the surface layer of soil.

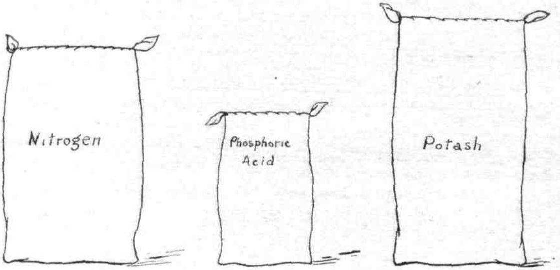
The reinforcement of farm manure with phosphorus is sound practice. Farm manure in comparison with commercial fertilizers is unbalanced. It may be cited for example that a 2-8-2 fertilizer mixture or one containing two per cent of ammonia, eight per cent phosphoric acid and two per cent potash is widely used. Ordinarily mixed farm yard manure contains about .5 per cent nitrogen, .25 per cent phosphoric acid and .6 per cent potash, thus being deficient in phosphoric acid. By supplementing the manure with phosphorus smaller applications of manure may be made with better results.



Relative amounts of nitrogen, phosphoric acid, and potash in a 2-8-2 commercial fertilizer.

Figure 11.

The Phosphorus Balance of Michigan Soils. The amount of phosphorus lost annually from Michigan's soils is of great concern to the commonwealth. The figures in table I show as nearly as can be estimated the quantity of this element of plant-food removed by the staple crops and pastures, but not including fruit, mint, chicory, or vegetables such



Relative amounts of nitrogen, phosphoric acid and potash in farm manure

Figure 12.

as the onion, cucumber, cabbage and others, and in addition the amount of phosphorus returned to the soil in farm manures and commercial fertilizers. The fertilizers are considered to carry 10 per cent phosphoric acid.

TABLE I.—PHOSPHORUS BALANCE OF MICHIGAN SOILS.

	Pounds annually.
Phosphorus removed from the soil	77,999,678
Phosphorus returned in farm manures	46,304,763
Phosphorus returned in commercial fertilizers	8,732,000
Total phosphorus returned to soil	55,036,763
Phosphorus lost from the soil	22,962,915

These figures reveal rather striking conditions. There are being lost annually about 22,900,000 pounds of phosphorus from our soils. It is true that as yet we are not ready to ignore the phosphorus content of many of the soils, that is supply it in sufficient quantities to meet the requirement of the crops grown. Yet we are approaching this situation and in case of many fields it seems to have been reached, and to these phosphorus should be added in excess of the amount removed by the

crops produced. There are soils now practically sterile which within the memory of the older inhabitants produced abundant yields of crops. Assuredly this condition is not due wholly to the depletion of available phosphorus, but that it is an important factor is evidenced by the beneficial results received by many farmers who have made use of phosphatic fertilizers.

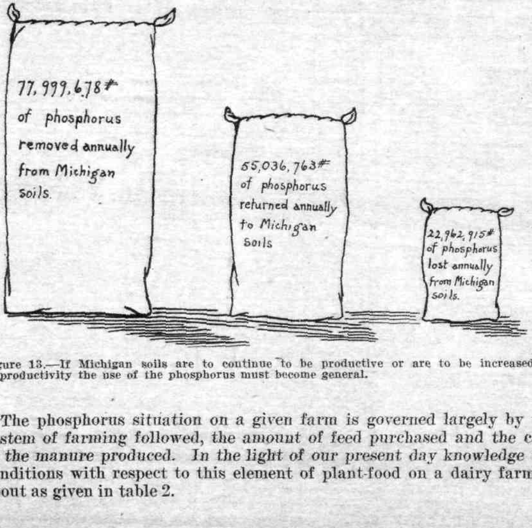


Figure 13.—If Michigan soils are to continue to be productive or are to be increased in productivity the use of the phosphorus must become general.

The phosphorus situation on a given farm is governed largely by the system of farming followed, the amount of feed purchased and the care of the manure produced. In the light of our present day knowledge the conditions with respect to this element of plant-food on a dairy farm is about as given in table 2.

TABLE 2.—THE PHOSPHORUS BALANCE ON A DAIRY FARM WHICH CARRIES 20 COWS, 10 CATTLE, 20 HOGS AND 5 HORSES.

Crops produced.	Phosphorus content pounds.	Consumed by stock.		Sold from farm.		Returned to soil.	
		Produce.	Phosphorus content pounds.	Produce.	Phosphorus content pounds.	Produce.	Phosphorus content pounds.
Hay, 10 acres, 20 T.	88.0	20 T.	88.0				
Corn, 10 acres:							
Grain, 400 bu.	64.0	250 bu.	40.0	150 bu.	24.0		
Stover, 12 T.	*32.0*	*7.5 T.*	*20.0*			4.5	12.0
Corn, 10 acres:							
Silage, 100 T.	100.0	100 T.	100.0				
Oats, 20 acres:							
Grain, 1,200 bu.	139.2	800 bu.	92.8	400 bu.	46.4		
Straw, 30 T.	52.8	Fed 6.5 T.	11.4	6 T.	10.56		
		Bedding 17.5				17.5	30.84
Barley, 10 acres:							
Grain, 340 bu.	54.4	340 bu.	54.4				
Straw, 11 T.	19.0			11 T.	19.03		
Beans, 10 acres:							
Grain, 200 bu.	64.0			200 bu.	64.0		
Straw, 8 T.	20.8					8 T.	20.8
Pasture, 30 acres.	210.0		210.0				
Purchased:							
Bran, 7.5 T.		7.5 T.	192.0				
Total phosphorus.	844.2		809.1		163.99		63.64

Loss in process of digestion and handling of manure, 40 per cent 326.6

482.5 phosphorous returned to soil in manure. 482.5

Total phosphorous returned to soil 546.14

Total phosphorous lost from farm, 298.06 lbs.
Pounds of 16 per cent acid phosphate needed to make good the loss, 4,270.

It is to be noted if one purchases 7.5 tons of bran, feeds it and considers that 40 per cent of the phosphorus does not return to the soil due to its retention by the animals and losses from the manure, there is a deficit of 298.06 pounds of phosphorus on a 100-acre dairy farm, the conditions being as outlined. There are required 4270 pounds of 16% acid phosphate to replace the annual loss.

The situation is different on a farm where less stock is fed, less feed purchased and much of the crops produced is sold. Under the conditions outlined there are required annually 6830 pounds of 16 per cent acid phate to meet the losses entailed on a 90-acre farm.

That the system of farming followed, the amount of feed purchased and the care of the manure produced govern the phosphorus balance on a farm is further supported by chemical examinations of representative

The writers are indebted to Professors Brown and Edwards of the Animal Husbandry Department and Professor Eidell of the Dairy Department for data regarding the weight, feeding and care of animals, used in compiling tables 2 and 3.

soils which have been cropped for about seventy years without the return of much fertilizing materials, and the corresponding virgin or uncropped soils. Such tests of course show wide variation in the changes in composition of soils from different farms. In some instances they are negligible; in case of others as much as sixty per cent of the phosphorus of the surface soil has been removed, while forty per cent losses are common. Later on the effect of different systems of farming or the changes in the composition will be reported.

TABLE 3.—THE PHOSPHORUS BALANCE ON A 90 ACRE "MIXED" FARM WHICH CARRIES 6 COWS, 4 CATTLE, 14 HOGS AND 5 HORSES.

Crops produced.	Phosphorus content pounds.	Consumed by stock.		Sold from farm.		Returned to soil.	
		Produce.	Phosphorus content pounds.	Produce.	Phosphorus content pounds.	Produce.	Phosphorus content pounds.
Hay, 10 acres, 20 T..	88.0	17 T.	74.8	3 T.	13.2	....	....
Corn, 15 acres:							
Grain, 600 bu.....	96.0	287 bu.	46.0	313 bu.	50.0	....	....
Stover, 18.1 T....	48.0	11.3 T.	30.0	....	....	6.8 T.	18.0 T
Oats, 20 acres:							
Grain, 1,200 bu...	139.2	800 bu.	92.8	400 bu.	46.4	....	....
Straw, 30 T......	52.8 T.	Fed 8 T.	14.1				
		Bedding 8 T.	....	14.1 T.	24.6	8 T.	14.1
Barley, 10 acres:							
Grain, 340 bu.....	54.4	....	....	340 bu.	54.4	....	....
Straw, 11 T.......	19.0	....	....	11 T.	19.0	....	....
Beans, 15 acres:							
Grain, 300 bu.....	96.0	....	....	300 bu.	96.0	....	....
Straw, 1.2 T......	31.2	....	....	....	....	1.2	31.2
Potatoes, 5 acres:							
1,000 bu.........	39.9	....	....	1000 bu.	35.9	....	....
Pasture, 15 acres....	78.7	....	78.7	....	....	....	....
Total phosphorus...	743.2	....	336.4	....	343.5	....	63.3

Loss in process of digestion and handling of manure, 40 per cent............ 134.6

201.8 phosphorus returned to soil in manure. 201.8

Total phosphorus returned to soil 265.1

Total phosphrus lost from farm, 478.1.
Pounds of 16 per cent acid phosphate needed to make good the loss, 6,830.

Phosphorus in Some Michigan Soils. The phosphorus content of Michigan's soils varies. The members of the Soils Section have been engaged in a systematic study of the representative soils of the State. In addition to other investigations, the composition of the samples collected has been determined. The results, thus far obtained, that bear upon the phosphorus situation are set forth in Table 4. The phosphorus content of the representative soils of Berrien, Cass, St. Joseph, Branch, Van Buren, Allegan, Newaygo, Mason, Manistee, Ingham counties and the Old Lake Bed of Eastern Michigan is given.

Representing as they do much of the lower peninsula these figures are of great interest and importance to the future welfare of the commonwealth. They show that our soils are not high in phosphorus. A soil that contains a total of about 2000 pounds of phosphorus per acre to a depth of seven inches is considered to be well supplied with this element of plant-food. The pine and scrub oak lands usually are extremely low in this substance, the prairie soils are highest and others occupy an intermediate position with respect to their phosphorus content.

Figure 14.—Bundles of wheat from equal areas of fertilized and untreated silt loam soils. The bundles on the right in each group were grown on land receiving 200 lbs. per acre of 1[illegible] per cent acid phosphate.

Table 4. *Phosphorus in the surface layer of typical Michigan soils.*

BERRIEN COUNTY SOILS.

Description.	Pounds per acre
Undulating to level sand known as Covert sand—scrub oak lands. Areas occur in the S. W. corner of county. Principally in New Buffalo, Chickaming and Lake townships..................	884
Heavy silt loam with heavy subsoil called clay soil. Hickory, beech and maple land. Occurs principally in Hagar township..	890
Rolling sand to heavy sandy loam with sandy clay subsoil. Oak and hickory land. Large areas occur S. W. of the center of the	

Description.	Pounds per acre
county. Weesaw, Berrien, Niles and Three Oaks, Buchanan, Lake, Bertrand, Oronoko townships	796
Level sand along St. Joseph and Paw Paw river and Dowagiac creek. Oak land	1248
Undulating to rolling sand largely timbered with maple, elm, oak, hickory, large area around Arden	775
Rolling sand original timber beech, oak, hickory and maple, fruit land. Occurs principally in Watervliet, Bainbridge and Pipestone townships	1206

Figure 15.—Some soils respond to nitrogen, phosphorus and potassium in the initial stages of their improvement. Rye growing on Cass County farm, on the right no treatment, on the left, nitrate of soda, acid phosphate and potash.

CASS COUNTY SOILS.

Undulating to rolling sand with a sandy subsoil. Oak and beech land found in Milton, Howard, LaGrange, Wayne, Silver Creek townships	1018
Undulating to rolling sandy loam, original timber beech, maple, hickory, basswood. Occurs principally in LaGrange, Silver Creek and Porter townships	1117
Undulating loam, original timber beech, maple, hickory and basswood. Areas found in Pokagon, Penn, Calvin, Mason, Porter, Newberg, Marcellus and Volinia townships	1227
Prairie, Volinia, Penn and Milton townships	1903

ST. JOSEPH COUNTY SOILS.

Prairie soils, areas near Colon, Flowerfield Station, Mendon, Sturgis, White Pigeon and Three Rivers	1093
Level sand typical of large areas throughout the county—oak, maple	787

Description.	Pounds per acre
Undulating sand with yellow sand subsoil. Areas in Colon, Constantine, Park and Mendon townships. Oak, beech, maple	914
Undulating to rolling sandy loam to silt loam. Beech and maple land, large areas in Leonidas and Mendon townships.........	1312
Undulating sandy loam with sandy subsoil—beech, maple and oak land. Areas found in Flowerfield, Sturgis, Fawn River and Park townships....................................	954

BRANCH COUNTY SOILS.

Undulating to rolling sandy loam to silt loam, Hickory, maple, oak and beech. Large areas in all townships except Bethel and Noble	1115
Level sand areas throughout county, oak......................	992
Level sand to sandy loam. Oak, maple. Areas in Ovid, Butler, Giriad, Sherwood, Union, Batavia and Matteson.............	1139
Undulating to rolling sand to sandy loam. Oak, hickory, beech, occurs principally in the eastern part of Bethel township.....	1001
Undulating sand (glacial outwash) southwest corner of Noble township, poplar, red oak, elm, ash........................	1017

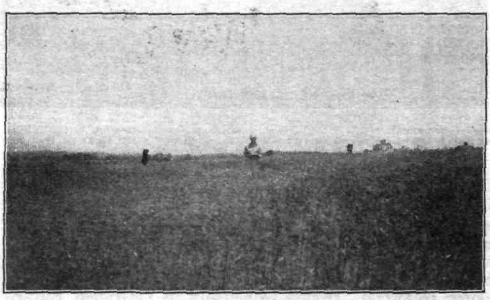


Figure 16.—The response of crops to applications of phosphorus to some soils is remarkable. *Oats growing on Van Buren County soil; on the right the soil received 2000 pounds of raw* rock phosphate per acre the previous year, on the left no phosphate was applied.

VAN BUREN COUNTY SOILS.

Poor rolling sand, original timber oak and beech, occurs principally in Decatur, Porter, Almena, Antwerp and Paw Paw townships	971
Level to undulating sand, oak openings, large areas throughout county	985

Description.	Pounds per acre
Rolling sandy loam called Arlington Hills, timber oak, hickory and beech, areas occur in Lawrence, Bangor, Waverly, Arlington, Columbia and Bloomingdale townships	884
Rolling sand, oak and beech timber found in the S. W. corner of county in Hartford, Keeler, Bangor and Covert townships	992
Level poor sand of Covert township. Scrub oak land	659
Rolling sandy loam occurs principally in Geneva township. Original timber hickory, maple, beech and basswood	568
Level sand, along Paw Paw River, Oak land	1017

ALLEGAN COUNTY SOILS.

Upland loam soils originally timbered with beech, maple, oak and walnut. Large areas in the west central part of the county. Small area throughout the county	627
Clay loam soils originally growing hickory, elm and oak. Areas generally distributed in the county	974
Low lying dark colored sandy soil, original timber oak and walnut. Areas throughout the county	664
Rolling sandy loam originally growing oak, maple, beech and hickory. Large areas in the eastern half of the county. Smaller areas generally distributed	794
Black clay soil which was covered with elm, oak and maple. Large areas lying between Allegan and northwest corner of the county. Small areas distributed throughout the county	1035

MASON COUNTY SOILS.

Ash, elm, soft maple	1043
Pine soils	559

MANISTEE COUNTY SOILS.

Level to undulating sand; original timber pine, second growth scrub oak. Lower areas, poplar. Areas found throughout the county	612
Level to undulating sand; originally grew large pines. Second growth principally oak. Areas of this soil are distributed throughout the county	722
Undulating to rolling sand. Mixed timber land. Large areas found in the northwest part of the county	806
Level sand along the Manistee river originally grew pine, second growth oak	613
Level to undulating sand. Original timber pine, second growth scrub oak, soil quite shallow. Large areas found in the southeastern part of the county	584
Level to undulating sand originally growing maple. Soil is deeper than the pine lands. Areas found in Maple Grove, Bear Lake and Brown township	694

Description.	Pounds per acre
INGHAM COUNTY SOILS.	
Undulating silt loam to clay loam, original timber beech and maple. Areas occur in Leroy, Delhi, Alaiedon and Wheatfield townships	1182
Undulating sandy loams to loams, original timber beech, maple, oak and basswood, occurs principally in Williamston, Vevay, Wheatfield, Delhi and Alaiedon townships	855
Rolling sand, original timber scrub oak and poplar, with some maple and elm. Areas occur in Ingham, Bunker Hill, Meridian and Onondaga townships	912
Rolling sandy loam to silt loam. Original timber beech, maple, elm, oak and hickory. Areas occur in Onondaga, Stockbridge, Aurelius, Leslie, Williamston and Ingham townships	952
Level sandy soils growing oak and poplar. Found principally in Locke, Williamston, Leslie, Bunker Hill and Stockbridge twps.	1303
Rolling silt loam with heavy subsoil. Hardwood land—areas found in Brown, Bear Lake and Manistee townships	718

Figure 17.—Some soils are very deficient in phosphorus and where applied its effects on plants are very striking even in the early stages of their development. In the center of photograph is shown wheat growing on untreated sandy loam soil. The remainder of the field received 200 lbs. per acre of acid phosphate. (Courtesy of H. B. Blandford)

NEWAYGO COUNTY SOILS.	
Level brownish yellow sand. Original timber pine, second-growth scrub oak. Large areas in Garfield, Brooks, Croton, Big Prairie and Everett townships	800
Level sand, subsoil gray "water sand." Original timber pine, second-growth oak and popular. Areas found in the southwestern part of the county	519
Rolling sand with sandy subsoil. Original timber hardwood. Areas around Fremont and Grant	778
Rolling brown sandy loam to silt loam with heavy subsoil. Hardwood land. Areas near Aetna, Ashland Centre and Grant	1105

Description.	Pounds per acre
Gently rolling grayish brown sand. Original timber pine, second-growth oak. Areas in Troy township..................	538
Flat gray and sand plains found in the northwestern part of the county. Original timber pine, second-growth poplar and scrub oak	506
Gray sand with yellow to reddish brown sand subsoil. So-called "flats" of the north central part of the county. Original timber pine. Very little second growth......................	552
Level brown to gray sand. Soil quite deep. Large pine land areas in Barton and Norwich townships....................	748
Gray sand with reddish yellow sand subsoil. Large pine land. Large areas in Goodwell and Wilcox townships..............	765
Rolling brown sand with clayey sand subsoil, original timber large pine and hardwood. Large areas in Ensley township...	1317
Rolling brown to gray sandy loam with heavy subsoil. Hardwood land areas in eastern Big Prairie and Goodwell twps....	758
SOILS OF THE LAKE BED AREA IN EASTERN MICHIGAN.	
Undulating to slightly rolling brown silt loam on yellowish brown clay, pre-dominating type of soil in Macomb, St. Clair and Huron counties, and large areas occurring in Sanilac and Oakland counties..................................	1304
Level to undulating or rolling brown sand underlaid by yellow sand and then clay. Areas occur along Lake Huron and the St. Clair and Black rivers. Several areas occur in Huron county	530
Undulating to gently rolling brown sandy loam containing some gravel, principally in St. Clair, Macomb and Oakland counties	1092
Sandy ridges of southeast corner of the Lake Bed Area.........	1050
Level to undulating sand underlaid at varying depths by clay. Southeast corner of the Lake Bed.........................	1786
Undulating to gently rolling sandy loam with loamy subsoil, occurring where larger streams enter the Lake Bed Area........	751
Black sandy loam underlaid by grayish sandy clay which grades into a heavier soil. Areas in Saginaw, Bay and Genesee county	1115
Black silt loam on yellowish brown clay subsoil, level to undulating. Areas occur from the thumb south to the State line	1610
Low lying silt loam with water table about 24 inches below the surface. Used for hay and pasture in the southeastern part of the Lake Bed Area	917
Dark colored sandy loam with a heavy subsoil, large areas of which occur in Saginaw and Bay Counties, and smaller areas in neighboring counties	1150
Dark colored silt loam on a heavy subsoil occurring in Iosco, Arenac, and other counties in the northern part of the Lake Bed Area	1216
Dark colored sandy loam with gravely subsoil forming the Utica plains of Macomb county	751

Description.	Pounds per acre
Dark colored loam soil with clay subsoil occurring in Gratiot and neighboring counties	1264
Dark colored silt loam underlaid with open sandy silt. Found in Sanilac and neighboring counties	785
Sandy soil underlaid with sand for about 3 feet and then clay, *occurring in Midland and other counties in the northern part of the Lake Bed Area*	765

Figure 18.—Tomatoes, on the left no fertilizer, on the right acid phosphate. Sandy soil in Wayne County.

Results Obtained From the Use of Phosphorus. A safe margin of profit may be derived from the judicious use of phosphorus on many of Michigan's sands, loams, clays and mucks. In determining the profits derived from the use of phosphatic or other fertilizers the increase in yield due to their application, the cost of the treatment and the value of the product grown must be considered. Let us suppose for example a 200-pound per acre application of 16% acid phosphate, costing $3.20 on the land, increases the yield of wheat 9 bushels, or oats 25 bushels, and the clover following these crops 1200 pounds per acre. The wheat sold for two dollars per bushel at the farm, the oats at seventy cents and the clover hay was worth $15 a ton under one set of conditions. At another time the phosphate cost $2.00 on the land, the wheat brought $1.00 per bushel, the oats forty cents and the clover was worth $7.00 a ton at the farm. Now what are the net profits derived from the investment in the fertilizer? This question is answered in table 5.

TABLE 5.—COMPARATIVE RETURNS FROM THE USE OF ACID PHOSPHATE UNDER CONDITIONS OF HIGH AND LOW PRICES FOR PRODUCE AND FERTILIZER.

Crop	Increased yield due to fertilizer.		Value of increase.		Total value of Increase	Cost of Fertilizer.	Cost of lime.	Net profit from use of lime and fertilizer
	Grain	Straw	Grain per bu.	Straw and hay per ton.				
Wheat........	9 bu.	900 lbs.	$2.00	$3.00	....	....	....	....
Clover........	....	*1,200 lbs.*	....	*15.00*	$28.35	*$3.20*	*$3.50*	*$21.65*
Oats..........	25 bu.	1,250 lbs.	.70	3.50	....	....	....	....
Clover........	....	1,200 lbs.	....	15.00	28.69	3.20	3.50	21.99
Wheat........	9 bu.	900 lbs.	1.00	1.50	....	....	....	....
Clover........	....	1,200 lbs.	....	7.00	13.88	2.00	3.00	7.88
Oats..........	25 bu.	1,250 lbs.	.40	2.00	....	....	....	....
Clover........	....	1,200 lbs.	....	7.00	15.45	2.00	3.00	9.45

These figures show that when there is a substantial increase in yield from the use of phosphorus a greater profit may be derived under the first set of conditions, namely, high prices for fertilizer and crops grown, than under the latter, or lower prices.

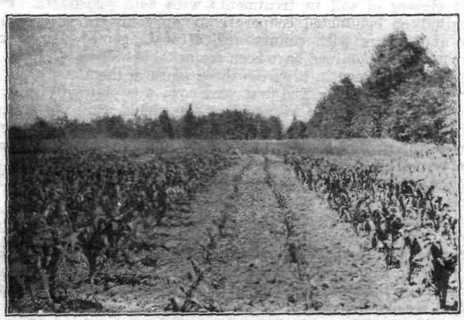


Figure 19.—Some soils are exceedingly responsive to fertilizers. The two rows of corn shown in the center of the photograph and several in the right were unfertilized. The others received 125 pounds per acre of a complete fertilizer. (Courtesy of C. M. Kidman)

Furthermore, there is a tendency to overlook the importance of increasing crop yields by means of lime, phosphates, manures and other materials to the farm management scheme. Suppose for example a live-stock farmer is able by the judicious use of lime and phosphate to grow satisfactory yields of alfalfa or clover and thereby decrease the consumption of high priced mill feeds, and in addition the grain production is increased

by the growth of legumes. This means that more livestock may be maintained more cheaply on the same acreage, or the same number on a smaller area with less labor.

TABLE 6.—HOURS OF HUMAN LABOR AND HORSE LABOR AND ACRES OF LAND REQUIRED TO PRODUCE THE SAME AMOUNT OF CROPS ON AVERAGE LAND AND LAND PROPERLY DRAINED, LIMED AND FERTILIZED.

Crop.	Amount produced	Average land.			Drained, limed and fertilized land.		
		Acres required	Man hours	Horse hours	Acres required	Man hours	Horse hours
Beans.....	195 bu.	24	840	984	10	350	410
Oats.......	600 bu.	20	252	454	9	113.4	204.3
Wheat.....	340 bu.	22	369.6	778.8	10	168	354
Hay.......	25 tons	20	98	362	11	53.9	199.1
Total....	....	86	1,559.6	2,578.8	40	685.3	1,167.4

This does not include the time required to haul, thresh or stack the produce.

A number of field tests have been made to determine the response of different classes of soil to treatments with acid phosphate. Some of these have been conducted cooperatively on county farms, some with farmers and others with county agricultural agents* In several instances the results obtained have been remarkable indeed.

Field tests have been in progress three years at the Van Buren county farm on sandy loam soil. The first year corn was planted on the experimental plots, but owing to an accident the yields were not taken. Observations made by Grantham during the growing season and a few days previous to the time of harvest of the corn revealed that the presence of either raw rock phosphate or acid phosphate increased the rate of growth even in the early stages of its development. It was estimated that the yield was increased seven bushels by the phosphorus.

The second year oats were seeded and the yield was increased by the phosphorus that the corn crop did not utilize, as shown by figures 5 and 16.

Interesting results have been obtained from field tests at the Cass county farm on sandy soil. These have been in progress two years, and each treatment is duplicated or in other words two different portions of the field receive the same treatment. The yield of rye on three plots is given in table 7. The acid phosphate and the potassium chloride were applied to soy beans the previous year, but the sodium nitrate was applied to the rye crop 50 pounds at the time of seeding and 50 pounds in early spring.

The writers are indebted to Mr. C. H. Graves, Farm Mgt. Demonstrator, for much of the data in the above table.

*At this time we desire to express our gratitude and acknowledge our indebtedness to these men for their commendable attitude toward the different lines of work undertaken, in fact the splendid spirit with which they have co-operated has made it possible for us to conduct the field tests.

Table 7. Result of field tests with rye on Cass Co. Soil 1918.

Treatment.	Yield of grain. Bus. per acre.
16 per cent acid phosphate 200 pounds per acre Sodium nitrate 50 pounds in fall and 50 pounds in spring Muriate of potash 200 pounds per acre	28.66
No treatment	15.60
Increase due to fertilizer	13.06
16 per cent acid phosphate 200 pounds per acre Sodium nitrate 50 pounds in fall and 50 pounds in spring	21.01
Increase in yield over untreated	5.41

This soil is deficient in vegetable matter, and responds to applications of complete fertilizers and its judicious use under normal conditions at least until clover is established in the rotation is profitable. Sweet clover responds vigorously to lime and phosphorus on this soil as illustrated by figure 21. When this crop is established in the rotation of course the nitrogen situation is largely solved.

Duplicate field tests were conducted on a sandy soil in Kent county in co-operation with H. G. Smith. Where 300 pounds of 16% acid phosphate were applied to the soil the yield of potatoes was materially increased.

Table 8. Results of field tests on Kent County Soils—1916.

Treatment.	Yields per acre bushel.
No treatment	100
300 pounds of 16 per cent acid phosphate	132

In cooperative experiments with S. A. Foster, of Ingham county, applications of lime as marl and either acid phosphate or raw rock phosphate have resulted profitably. (See figure 8.) The soil in question is a light sandy one, badly in need of lime as evidenced by the numerous failures to obtain suitable stands and yields of clover. Although this soil is not suitable for the production of oats, this crop was seeded the first season as a nurse crop for clover. The presence of the lime and phosphates increased the yield of oats and resulted in an excellent catch of clover. The following season the clover on the treated portion of the field outyielded that on the untreated land and was of much better quality. Moreover, about one bushel of seed was obtained per acre.

The co-operative investigations with several farmers have been gratifying indeed. The affects of acid phosphate when applied to several soils are illustrated by means of photographs.

Summary and Conclusions. The mineral element of plant-food, phosphorus, is popularly referred to as phosphoric acid and phosphate.

The three chief carriers of phosphorus are raw rock phosphate, bone meal and acid phosphate.

The application of phosphorus in suitable amounts to soils deficient

in it results favorably, increasing the root, leaf and stem development, aids in grain formation and shortens the growing period.

The effects on the soil are beneficial rather than harmful and its judicious use is a business-like procedure.

The most profitable amount to apply is governed by the nature of the soil, carrier used, as well as somewhat by the prices paid for the fertilizer and received for the crop grown.

The active form usually should be applied to the cash crops in the rotation and the other if used when sod, meadow or other crop residues are to be turned under.

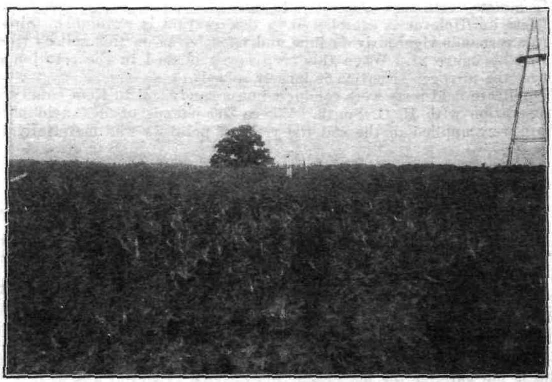


Figure 21.—Sweet clover responds vigorously to lime and phosphorus. On some of the light soils *potash is needed. This clover is growing on the same soil as the rye shown in Figure* 15. The result of lime and acid phosphate. It will solve the nitrogen and humus problem.

Phosphate fertilizers may be applied in several ways, but it is usually advisable to utilize a fertilizer distributor.

The phosphorus content of barnyard manure is relatively low in comparison with nitrogen and potassium and the reinforcement of it with one of the carriers usually is desirable.

As nearly as can be estimated about 22,900,000 pounds of phosphorus are lost from Michigan soils annually.

Analyses of samples of soil from fields long under cultivation and from uncropped adjacent land show that the change in the phosphorus content of the soil is governed by the system of farming followed. In several instances as much as forty per cent of phosphorus was found to have been removed from the surface soil, in others twenty per cent, and in still others little if any changes have taken place.

The phosphorus content of representative soils occurring in twenty counties has been determined. The results show that pine and scrub oak lands usually contain less than 750 pounds. Prairie soils are the highest in this element, while others occupy an intermediate position.

Not only should the cost of the fertilizer be considered in estimating the profit obtained from its use, but also the market price of the crops grown.

The increase in yield of crops by the use of phosphorus reduces both the man and horse labor hours, required to produce a given amount of material.

Many of Michigan's sand, loam, clay and muck soils respond profitably to applications of phosphorus. The readily available, or acid phosphate, is the most extensively employed.

By means of cooperative experiments with county agricultural agents many farmers, and managers of county farms we have been able to obtain information with respect to the phosphorus needs of several of Michigan's soils. In view of the favorable results obtained we are forced to conclude that every farmer who has not ascertained to his satisfaction, by means of thorough field trials whether the judicious use of phosphorus on his soil is a profitable investment, should do so.

GENERAL INFORMATION RELATING TO THE UPPER PENINSULA EXPERIMENT STATION.

Special Bulletin No. 90

BY R. S. SHAW, DIRECTOR.

The following notes of an historical character relating to the Upper Peninsular Station are reproduced from information contained in bulletin number 186, published in 1900. They convey a detailed description of soil and other conditions pertaining to the original 160-acre farm donated by the Munising Railway Company (Cleveland Cliffs Iron Company).

The State Legislature, at its regular session beginning January, 1899, passed an act appropriating $5,000.00 for the establishment and maintenance of an Experiment Station in the Upper Peninsula, the purposes of which are described in a portion of Section 4, of Act No. 114, as follows, viz.; "The said Board (State Board of Agriculture) shall carry on such experiments pertaining to agriculture and horticulture as in their judgment will be most beneficial to the agricultural interests of the Upper Peninsula."

"Late in July, 1899, the State Board of Agriculture, obeying the mandates of this law made a rapid survey of some of the agricultural sections of the Upper Peninsula and chose as the site of the Upper Peninsula Experiment Station the 160 acres constituting the southeast quarter of section 28; range 46 north; 21 west.

"This tract lies along the Munising railroad at Chatham, eighteen miles south and west of Munising, in Rock River Township, Alger County. It lies eight miles south of Au Train Bay, on the south shore of Lake Superior, and from 250 to 300 feet above its level. The farm is practically surrounded by a large belt of hardwood timber and the climatic conditions are similar to those existing over the major portion of the central section of the Upper Peninsula. Heavy snow covers the ground during the relatively long winters, preventing deep freezing of the soil. The snow lies on the ground continuously during the winter and until late in the spring when the sudden oncoming of the warm weather forces a rapidity of growth in the vegetable world unknown in regions farther south. The summers are hot and moist with no severe drouths. The autumns are long and usually delightful, although in areas surrounded by forests there is always danger of late frosts in the spring and early frosts in the fall, except along the shores of the great lakes. This danger, however, disappears with the removal of the forests.

"The soil on the tract selected is far from homogeneous. Near the little creek, which flows east through the center of the 160 acres and divides the tract into two approximately equal parts, there is an area of black muck, while on the terraces, which rise one above another on

either side, the soil is graded into a black sandy loam, containing plenty of lime and of great native fertility. The soil is spread rather thinly over the solid rock. The valley of the stream, which is known by the name of Slap Neck Creek, is approximately sixty-five feet deep, measuring from the surface of the water in the creek to the level of the upper terraces on each side. These terraces are bounded by gentle connecting slopes, all cultivable. The depth of the soil varies from two and one-half to three and one-half feet. The native timber is maple, for the most part, with a few basswood, cedar, wild cherry and elm. The large size of the trees, combined with the denseness of the forest, demonstrates the good quality of the land. The contour of the surface provides ample drainage, except in time of excessive rainfalls."

SUPERINTENDENT'S RESIDENCE AND OFFICE

"The 160 acres of land on which the Station is located was donated to the State by the Munising Railroad Company. The Company also agreed to clear, stump and grub the land as needed for experimental purposes and specifically agreed to clear, stump and grub twenty acres prior to May 1, 1900."

"After accepting the donation of the land, the State Board of Agriculture confided the planning and execution of experiments to the Director and Council of the Experiment Station, connected with the Agricultural College."

The following quotation is taken from the report of the Director of the Experiment Station, dated June 30th, 1911:

"A valuable addition in the form of land has been made to the Upper Peninsula Station at Chatham. Six hundred acres of land with the timber removed has been generously donated by the Cleveland Cliffs Iron Co., for the purposes of experimentation and demonstration. This

comprises the section on which the town of Chatham is located with the exception of forty acres which forms a part of the town site.

"As this property adjoins the present experimental farm of 160 acres diagonally and as it consists of the choicest land in Upper Michigan, the possibilities of developing a model farm are apparent under proper management. It is not intended to develop an experimental farm only, but to establish a model or demonstration farm operated on a commercial basis as well."

FARM HOUSE

The State Board of Agriculture, realizing the establishment of the live stock industry as the basis of a permanent agriculture and finding the original 160 acre farm inadequate for developing the live stock business on a sufficiently large scale, took the initiative in the negotiations leading to the addition of 600 acres more.

Mr. Leo M. Geismar was selected as Superintendent of the Station in the spring of 1900, and continued in charge up to March, 1912, when he was appointed to the position of Agricultural Extension Expert for the Upper Peninsula. At this time Roswell G. Carr, B. S., a graduate of M. A. C., was appointed and continued in charge until March, 1916, when he became Agricultural Agent for Ontonagon county. Since this time B. W. Householder, B. S., also a graduate of the college, has been in charge.

LANDS, BUILDINGS AND EQUIPMENT.

The original 160-acre farm is inventoried at $8,000.00. Of the recently acquired section, 140 acres, seeded and fenced, is valued at $4,200.00, and the remaining 480 acres of new and cut-over lands at $4,800.00. Thus the total estimated value of all lands at Chatham is $17,000.00.

The following is a list of buildings which have been provided very largely during the past half-dozen years:

Residence of Superintendent	$5,000 00
Farm house, 10 rooms, 24x28	4,500 00
Dairy barn 36x72	3,500 00
Root cellar (concrete) 20x50	1,000 00
Hog house 30x40	1,000 00
Ice house (concrete)	500 00
Poultry house	250 00
Original horse barn	250 00
Original granary	200 00
Sheep barn 36x100	2,400 00
Total value of buildings	$18,600 00

During the present season a combination horse and implement barn, 40x100, is being erected at a cost of about $7,500.00, thus meeting a long-felt need. The old seed house has been removed to the basement foundation originally occupied by the old farm house and the basement is being fitted up for use as dairy rooms while the upper floors are being equipped so that seeds and grains may be properly stored, cleaned, graded, etc., at all seasons of the year, no matter what weather conditions may be; this will include an expenditure of about $1,250.00. This season, also, a concrete manure pit, 24x60 feet, is being built to cost approximately $650.00. This manure storage house will connect directly with the carrying trackage already in operation in the dairy barn. Such storage facilities are made necessary because of the long periods of winter with depths of snow which make it impracticable to haul the manure out on the land at that time. These building facilities will complete the system planned on the home farm. Cheap, commodious shelter sheds for sheep and cattle and for the storage of fodder are now needed on the newer grazing lands of the larger farm.

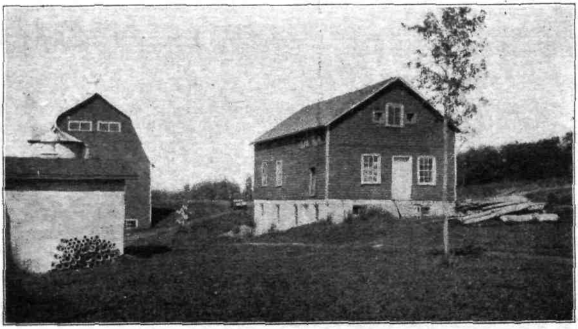
The original farm and those portions of the newer farm fenced, include a total of from 18 to 20 miles of fences, representing an investment of approximately $6,000.00. In large part, the cedar posts have been salvaged on the farm and heavy 48-inch woven wire has been procured in carload lots. Just prior to the war a very heavy all number 9 lateral wire fence was used, but more recently price conditions have enforced the use of a lighter type of fence. At least half of the cut-over land of the newer farm is still unfenced, permitting neighborhood stock to roam at will, interfering with seeding plans. A car of wire is now on hand, together with the necessary posts, but the labor situation has seriously interfered with construction work.

A continuous addition to the working equipment and facilities now represents the following investments:

Miscellaneous tools, supplies, etc.	$1,394 55
Implements and machinery	1,201 03
Feed and bedding	178 88
Crops	2,625 00
Seeds	176 50
Cleaning supplies (dairy)	26 75
Live stock	11,263 00
Total value equipment June 30, 1918	$16,865 71

FINANCIAL REPORT.

The history of the Upper Peninsula Experiment Station includes some years during which the State Board of Agriculture, with the limited funds at its disposal, was unable to appropriate as generously as seemed



SEED HOUSE, ICE HOUSE AND DAIRY BARN

desirable for the more rapid development of the Station. Three unfortunate occurrences resulted in withholding from the State Board of Agriculture, during the past ten years, nearly a million dollars which would have been used by the Agricultural College, Experiment Station and Sub-Stations. The first of these was the vetoing of a legislative appropriation bill, the second, the pronouncement as unconstitutional, of a mill tax bill by the Supreme Court of the State and the third consisted of the disastrous fire loss of the Engineering building and equipment at the College, a little more than two years ago. A perusal of the investments heretofore enumerated is expressive of the interest of the Board and the administration of the institution in the Station. For operating expenses, land clearing and building, $12,362.67 was appropriated for the year ending June 30, 1917, and for the ensuing year, $19,972.72.

FUNCTIONS OF THE STATION.

The land area of the Upper Peninsula includes 10,682,240 acres, a little less than one-third of the entire state. In 1909 the land area in farms amounted to 913,748 acres of which 340,602 acres were improved. The number of farms at that time was 8,994. As rapid strides have been made in the development of the agricultural conditions of the Upper Peninsula since 1909, the number of farms and area improved has been greatly increased.

The data heretofore given indicates the location of the Station at Chatham in the midst of a vast area where pioneering conditions prevail and where information is being sought on greatly varied problems pertaining to agriculture, including economic methods of land clearing, all phases of crop production, live stock breeding, housing, grazing and feeding, etc. Then these problems are further complicated by greatly varied soil and climatic conditions. The conditions are new ones, and many of the questions cannot be answered by information procured elsewhere. The institution must needs partake of both an investigational and demonstrational character and must necessarily include those business factors relating to comparative costs of production, transportation, marketing, etc.

It is apparent that close relations of cooperation must prevail with the Upper Peninsula Agricultural Extension Organization. The district experts and county agents are constantly coming in contact with problems requiring investigation. In so far as possible the Director and Superintendent will always be glad to endeavor to arrange for experiments to answer these questions and thereby extend to the Extension workers an invitation to make their wants known freely, even though it may not be possible to meet all the needs at once while the facilities of the Station are incomplete.

REPORT OF THE WORK OF THE UPPER PENINSULA STATION, INCLUDING DATA FOR YEAR ENDING JUNE 30, 1918.

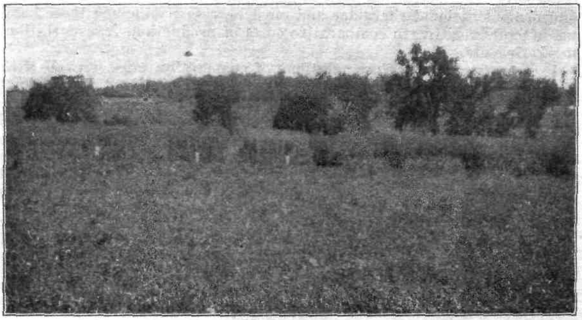
BY B. W. HOUSEHOLDER, SUPERINTENDENT.

CROP PRODUCTION.

Plant breeding by the comparison method, or variety tests, is being carried on quite extensively. During the summer of 1917 the following varieties were grown, viz.: corn 11, oats 8, barley 16, spring wheat 4, winter wheat 15, potatoes 6, and soy beans 1, covering an entire area of about six acres. Some of these are tested sorts from the East Lansing Station while others have been procured from neighboring states where somewhat similar conditions prevail. The purpose of the work being to determine the varities most adaptable to our climate and best suited to our needs means, that definite results cannot be procured for a period of years. Continuous, careful work, with the addition of new varieties and field tests in other portions of this region must follow.

In order to carry on experimental work in plant and animal breeding more trained help is needed, including labor with some appreciation of the methods to be followed and details to be observed. The varied soil and climatic conditions of this region prevent the acceptance of data procured elsewhere without first making a check as to the growth conditions and quality factors. The rapidity with which the Upper Peninsula is being developed agriculturally, is rapidly increasing the demand for information relative to cultural methods and possibilities of procuring the proper kinds of seeds in sufficient quantities.

In order to cooperate with and meet the needs of the County Agricultural Agents, a more extensive and greatly varied line of experiments will have to be inaugurated. The location of the station is not particularly favorable to demonstration efforts as it is not easily accessible to a large number of people. The county agents are being confronted with problems which the station must meet.



VARIETY TESTS, SPRING WHEATS, 1918

CROP ROTATION AND SOIL FERTILITY EXPERIMENTS.

The following crop rotation systems were started three years ago, viz.:

Rotation I. Virgin Soil, Barley, Clover, Roots or Potatoes.

Rotation II. Oats, Roots or Potatoes, Barley, Clover.

Rotation III. Roots or Potatoes, Oats and Peas, Alfalfa.

Rotation I will be conducted in duplicate, one set of plots being used in a test with stable manures and the other with both stable manures and raw rock phosphate, the same plan is to be followed with rotation II, while part of III will be treated with stable manure and the balance with manure and lime. Other rotations are being considered with both winter and spring wheat, rye, soy beans and possibly corn.

BARLEY.—Oderbrucker barley is being raised at Chatham as a substitute for corn because the early and late frosts interfere with the

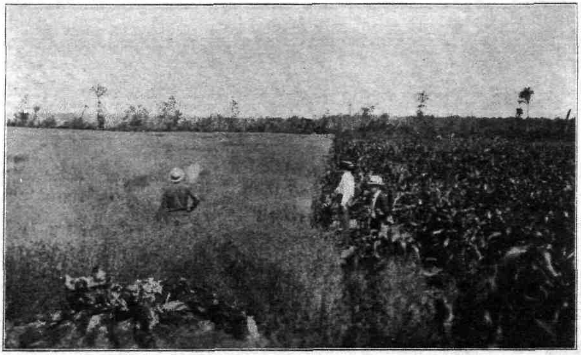
BARLEY, 1917

development of the latter at this point. Corn of suitable types may be grown for silage in the more favorable locations. But even where this is not possible cereals such as wheat, rye, oats, barley and legumes such as alfalfa and clovers together with enormous and easily produced root crops more than make good the deficiency. The barley crop in 1917 yielded 30.5 bu. per acre, machine measure. The pedigreed Oderbrucker variety was furnished to twenty-three farmers located in the different counties of the Upper Peninsula at $2.25 per bushel for seed. So far as known, this variety is the most promising for this region.

VARIETY TESTS, OATS, 1918

OATS.—Worthy oats which were bred out at East Lansing and which are being grown here in the larger field areas yielded 47 bushels per acre. Nine farmers were furnished seed of this variety.

ROOTS.—These were grown for dairy cattle and sheep feeding. Rutabagas grown on rough, new land comprising 2.37 acres, in cultivated drill rows 30 inches apart, yielded 46,114 pounds, or an average of 19.46 tons per acre. Because of the possibility of growing a variety of root crops, of high yield, there is need of printed material descriptive of the most up-to-date methods of production, in order to minimize the large amount of expensive labor usually involved.



OATS AND CORN, 1916

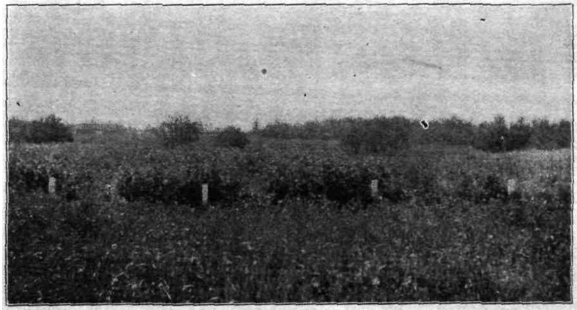
SILAGE CROPS.—Both corn and oats and peas were grown for silage. Because of unsuitable conditions the corn made very little growth and was frosted when it had attained a height of about four feet on August 26, 1917. The total yield for a total area of 3 acres was 6.64 tons or an average of 2.21 tons. It made a poor quality of silage.

The oats and peas yielded 65.5 tons of green material for silage from 6.41 acres or an average of 10.28 tons per acre. This crop made an excellent quality of silage which was relished by the dairy herd, resulting in the good returns illustrated in the dairy financial statement. The production of oat and pea silage is giving such good results as to require further investigation and more detailed reports as to methods of growing, siloing, feeding, etc.

SOY BEANS.—One-half acre of soy beans was planted both this year and last, but were damaged by frost in both cases.

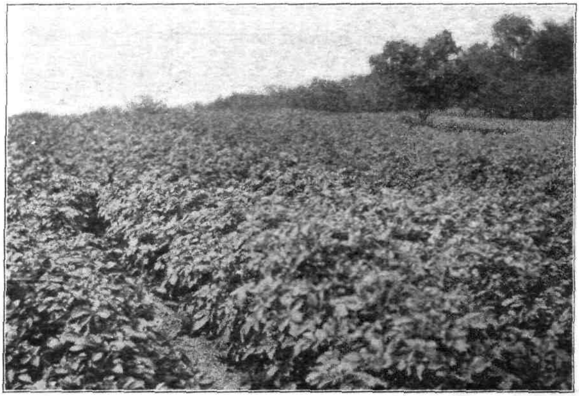
POTATOES.—Most of the potatoes grown on the Station Farm were in the demonstration plots. Five different varieties commonly raised in the Upper Peninsula were grown under varying conditions. The objects

SILAGE MIXTURE, 1917. *OATS 4 Ft. HIGH ; PEAS 4½ Ft.*



VARIETY TESTS, PEAS, 1918

sought were: (1) To determine the best spacing for obtaining the largest yield per acre of marketable potatoes, (2) to compare the results from green sprouted potatoes with those taken from a dark cool cellar both being planted at the same time, (3) to determine the largest yielding varieties, (4) to determine the economic and comparative values of applications of acid phosphate, stable manure, wood ashes and plantings on alfalfa sod, (5) planting by tuber unit system for seed selection and for demonstrating the unproductive qualities of some tubers, (6) to determine the effects of spraying with Bordeaux Mixture, (7) comparison of tip versus butt cuts for seed, (8) comparison of diseased and healthy



POTATOES, EXPERIMENTAL PLATS, 1917

seed, (9) use of seed dug in spring along with that harvested in the autumn. As the data procured from the foregoing tests is voluminous, it is to be published separately.

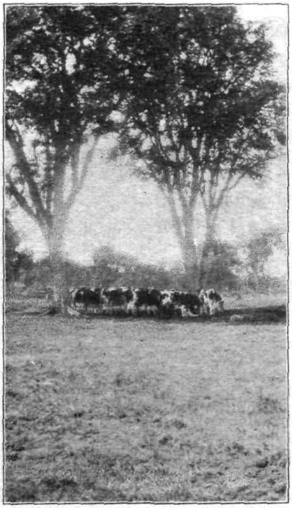
FRUIT.—A new orchard was started this spring containing the following varieties, viz.: Apples—Yellow Transparent, Duchess, Wealthy, Fameuse, Northwestern Greening, Wolf River, Alexander and Pewaukee and North Star, Crabs—Hyslop and Martha. Cherries—Montmorency, Early Richmond and English Morello.

The varieties selected were chosen largely as the result of observations of county agents in Alger and adjacent counties. Though the original orchard has not been a success, it is the plan to continue the work along this line. Past experiences show conclusively that only a very limited number of varieties of apples can succeed under Chatham conditions, that the soil should be deep and substantial, the site well drained and

protected and that the trees must be headed strongly without weak crotches and that great care must be exercised not to prune severely, keeping the heads rather full for protection.

Small fruits as currants, gooseberries, raspberries and strawberries yielded well.

GARDEN VEGETABLES.—Owing to the lateness of the spring of 1917, most garden truck was delayed in its growth. Beans were destroyed by frost on August 28th. This spring, (1918), beans, sweet corn and tomatoes were badly damaged by frost after starting.

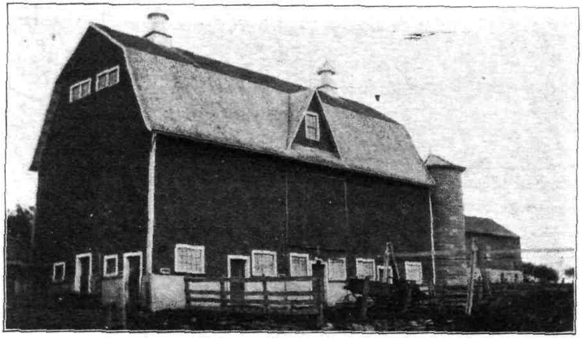


PART OF DAIRY HERD

LIVE STOCK SITUATION.

The Upper Peninsula comprises a vast area, a little less than one-third of the state. The present condition of the land area may be divided into four groups, viz.: (1) timbered, (2) cut-over, (3) undrained and (4) broken, hilly and sandy lands. Enormous areas have splendid agricultural possibilities when developed. The figures which follow include some costs of production at the station which would not arise in the case of the private farmer for the following reasons: (1) The de-

tailed work of weighing feed, milk, etc., recording the same and caring for animals as individuals or in groups in order to get definite accurate results, more than doubles the labor cost. (2) The station farm has insufficient cleared land in proportion to its live stock, resulting in heavy purchase of feeds. The pressing need for stimulating the live stock industry seemed to warrant the rapid increase of herds and flocks. (3) Transportation has added heavily to costs of all imported materials. Chatham is nearly four hundred miles distant from Chicago.



DAIRY BARN AND SILO

DAIRY.

The following figures are given in detail to illustrate more clearly the work of the station, and the qualifying factors just mentioned should be borne in mind.

The Station dairy herd numbers seventeen heifers, fourteen cows and one bull at the present time. An average of twelve cows were milked through the year. The average milk production of these cows was 10,356 pounds. Six of these cows were only a little past two years old at the time of freshening.

Five of the best ones were used in conducting ration tests. The object of the ration test was to enable us to determine the economic value of each kind of succulent feed in the production of milk, and in maintaining the general health of the animals. The feeds used in conducting this test were: Roots versus oat and pea silage, and the combination of roots and oat and pea silage versus roots alone, and versus silage alone. This test was started on December 25, 1917, and carried through to April 8, 1918. The cows were fed for a period of one week on one kind of feed, then an intermission of one week was used in changing them over to another feed, and so on alternately until the end of the tests. Each test was carried on in triplicate.

The average feed costs taken from triplicate tests, per 100 pounds of milk produced are:

Feed in combination with roots and silage	$1.42
Feed in combination with silage	1.286
Feed in combination with roots	1.662

The hay and grain allowance in this test were kept constant. The hay was very largely clover and the grain was made up of the following parts by weight:

Bran	4 parts
Ground corn	2 parts
Ground oats	2 parts
Gluten	1 part
Oil meal	1 part

Good health was maintained by all of the cows continuously.

FILLING CEMENT BLOCK SILO WITH PEAS AND OATS

FINANCIAL STATEMENT OF NEW YEAR'S WORK.

Investment:

Dairy barn	$3,500 00	
Twelve cows @ $250.00	3,000 00	
Nine heifers @ $100.00	900 00	
Bull @ $150.00	150 00	
Equipment, besides barn	500 00	
Land pastured 40 acres @ $25.00	1,000 00	
		$9,050 00

Present Valuation of Herd:		
Fourteen cows @ $250.00	$3,500 00	
Seventeen heifers @ $100.00	1,700 00	
Bull @ $150.00	150 00	
		$5,350 00
Costs:		
Labor $166.80 per month for 7 months	$1,167 60	
Labor $89.51 per month for 5 months	447 55	
Hay, 39 tons 28 pounds @ $21.16	825 26	
Bran, 8.2 tons	289 00	
Ground feed, 1 ton	52 36	
Gluten, 3,500 pounds	103 25	
Oil cake, 4,500 pounds	133 00	
Ground corn, 9,233 pounds	361 33	
Middlings, 200 pounds	5 20	
Ground oats, 8,560 pounds	202 84	
Beet pulp, 3,000 pounds	63 00	
Roots, 75 tons @ $5.33	399 75	
Silage, 65 tons @ $6.16	400 40	
Salt	2 45	
Medicines	24 75	
Sundry items	82 24	
Veterinary services	20 54	
Bedding	122 72	
		$4,703 24
Interest on investment, $9,050.00 @ 6%	$543 00	
		$5,246 24
Receipts:		
Cash receipts:		
Bulls sold, 11	$652 00	
Cows sold, 6	874 36	
Hide	11 62	
Cream	1,347 96	
Milk	450 84	
Cash returned on tickets	56 41	
		$3,393 19
Other receipts:		
Manure 299 tons @ $1.00	$299 00	
Increased valuation	1,300 00	
Miscellaneous	59 24	
Skim milk to pigs, 5 gals. per day @ 4c	73 00	
Credit ½ labor charge (extra labor on account exp. work)	807 53	
		$2,538 77
		$5,931 96
Net profit:		
Total receipts	$5,931 16	
Total costs	5,246 24	
Profit		$685 82

The valuation placed on cow manure is $2.74 per ton (Henry's Feeds and Feeding). I have allowed only $1.00 per ton. This leaves $1.74 per ton to cover waste and cost of putting on field.

STATEMENT OF WORK ON BEEF CATTLE. 1917.

A carload of 26 average grade, two-year-old steers was purchased off the Chicago market on June 15, 1917, for the purpose of learning whether they could be handled at a profit or not. Following is statement of the results obtained:

Twenty-six steers, average weight 759 lbs. cost at Chicago		$1,638 55	
Freight, Chicago to Chatham		64 00	
Freight, Chatham to Lansing		92 68	
Labor at Chatham		15 00	
Pasture at Chatham		104 00	
Feed at Chatham		21 31	
Feed at College:			
Silage	$206 44		
Hay	71 64		
Grain	97 28		
Feed and straw for shipping	10 00		
		$385 36	
			$2,320 90
Receipts for 22 steers, Bishop, Bullen & Holmes, Detroit, Mich.		$2,034 31	
Receipts for 2 steers, slaughtered at College		163 28	
Receipts for 1 steer, slaughtered at Chatham		84 02	
Receipts for 1 steer, Wm. Robarge, Forest Lake		75 25	
			$2,356 86
Profit			$35 96

This carload of steers was in healthy condition when purchased, yet quite thin. This worked to our advantage, as there was plenty of room for putting on flesh. The pasture that they grazed on had luxuriant growth and was very good.

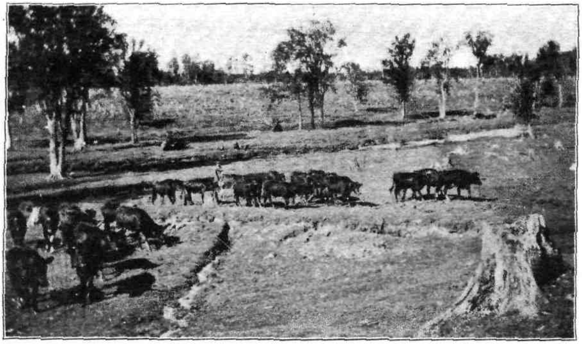
It will be seen from the statement that our net profit was only $35.96, but, that $104.00 was charged against the steers for pasture. Had not the steers been purchased this pasture would have been wasted, except that which would have returned to the soil in the form of fertilizer. So, in fact the Station was paid clear of all expenses $139.96.

A very large percentage of the profit was eaten up, so to speak, in transportation and shrinkage. The freight from Chicago here was $64.00 and from here to Lansing $92.28 or a total of $156.68. The average weight of these steers at Chicago, June 15th was 759 pounds; at Chatham a few days later, 694 pounds, and at time of loading for shipment to

Lansing the following October was 908 pounds. It would have been much better if these cattle could have been purchased and put on grass at least four or five weeks earlier. As it was, however, the gains on grass were excellent.

SHEEP.

The Station had 268 head of sheep including lambs July 1, 1917. Out of this number 4 were sold, 10 were killed by dogs, 5 died and 11 were unaccounted for. This left 238 head which were taken into winter quarters November 22, 1917. They were in excellent condition being grazed about three weeks in a field where oats, barley and rutabagas had been harvested.



CAR LOAD OF BEET CATTLE ON PASTURE, 1917

Breeding Season:

Immediately after bringing the ewes into winter quarters, rams were placed with them to take advantage of their flush condition. The first forty of these grade ewes to drop lambs gave birth to 63 lambs, an increase of 157½%. The remaining 101 ewes gave birth to 118 lambs, an increase of 116.8%. It is thought that the decrease in the percentage of lambs is due to the ewes being bred after they had been fed on clover hay which lowered their flush condition.

It is claimed that ewes, if bred while flushed will drop more twins. Our experiment this year bears out this statement.

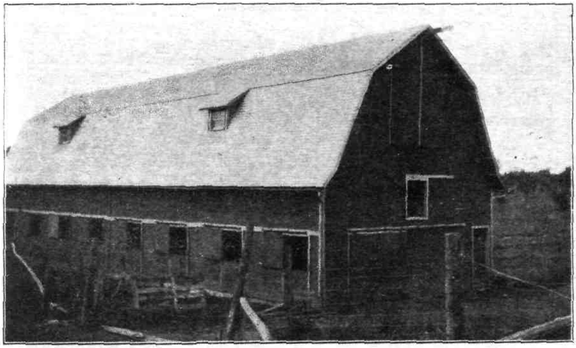
Management of Rams:

The rams were placed with the ewes from 8:00 to 10:00 in the morning. They were then moved to pens by themselves and fed liberally. At 4:00 p. m. they were put back with the ewes and left until about 6:00 p. m., when they were again put by themselves and fed. It has

been found that by handling rams in this manner, the last lambs dropped are just as strong and vigorous as the first. Four rams were used.

Winter Rations:

The winter ration given most of the ewes consisted of hay. Part of it was a very poor quality of mixed hay and part of it was of a very good grade of alsike. Most of the ewes came through the winter in good shape on this feed. Whenever one of them showed a tendency to become emaciated, she was separated from the rest of the flock and grained. All of the ewes were fed $\frac{1}{4}$-pound each daily grain mixture of barley, oats and bran in equal parts, beginning 3 weeks previous to lambing. This allowance was increased to $\frac{1}{2}$-pound each after lambing.



SHEEP BARN

There were no losses in this flock from the time they were taken into shed November 22, 1917, until the second day of April, 1918. Since then the deaths number: 5 ewes, 2 wethers, 2 yearling ewe lambs, and 3 lambs. One ewe and 2 lambs were killed by dogs; 1 lamb by an automobile, 2 ewes were too weak to give birth to their lambs; and 2 died from eversion of the uterus. Cause of the death of the others not known.

Ration Experiments:

Forty-eight lambs were divided into lots of six each.

Lot 1 was fed on oat and pea hay and roots for 60 days.
Lot 2 was fed on clover and grain for 100 days.
Lot 3 was fed on clover and grain and roots for 100 days.
Lot 4 was fed on oat and pea hay for 60 days.
Lot 5 was fed on clover and corn for 100 days.
Lot 6 was fed on clover and barley for 100 days.
Lot 7 was fed on clover and corn and roots for 100 days.
Lot 8 was fed on clover and barley and roots for 100 days.

The purpose of carrying on this experiment is to find out which combination is of the greatest economic value in the production of growth of animals and yield of wool. As the experiment has been in operation only one year, the data compiled is not sufficient for the drawing of any conclusions.

Lambing Season:

Throughout the lambing period extra good care was given to the flock. Prompt attention was given to all new born lambs, and in every case the mother ewe and lamb or lambs were moved from the rest of the flock, and put into pens by themselves for a period of two or three days. Here they became acquainted with each other and very little trouble was experienced after turning them out.

PART OF FLOCK AT WINTER QUARTERS

RECORD OF LAMBING SEASON, SPRING OF 1918.

Kind of Sheep.	No. of Ewes.	No. of Lambs.	Deaths.
Grade Western	121	158	14
Hampshire	12	15	2
Rambouillet	8	8	1
Total	141	181	17

Percentage of living lambs—116.3.

Pasture:

The flock was turned out on pasture on April 20th and very littl bad weather followed this date. The pasture has been very good anc the sheep are in excellent physical condition.

Distribution of Rams:

Four pure bred Hampshire rams were sent out from this Station fo breeding purposes at very reasonable prices. One was furnished a Boys Club free of charge.

FINANCIAL STATEMENT.

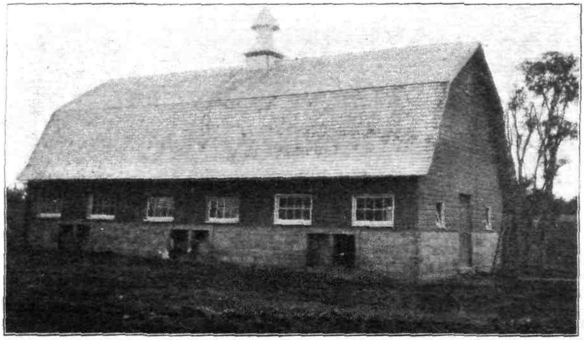
Investment:		
Valuation of flock July 1, 1917	$1,719 00	
Valuation of building	2,400 00	
Land pastured (60 acres estimated)	1,500 00	
		$5,619 00
Costs:		
Hay 58.53 tons, average value $25.77	$1,508 64	
Miscellaneous	18 35	
Salt	2 45	
Labor, 4 hours daily for 150 days @ 25c	150 00	
Labor, 160 hours for shearing @ 25c	40 00	
Lambing season, 12 hours daily for 18 days @ 25c	54 00	
Summer care, 105 hours @ 25c	26 65	
Grain	273 46	
		$2,073 15
Interest on investment $5.619.00 @ 6%	$337 14	
Total cost		$2,410 29
Receipts:		
Wool 1,498.5 pounds @ 65c per pound	$974 02	
4 rams sold	90 30	
Credit on feed not used	78 79	
Miscellaneous	3 25	
Manure value (estimated at ½) 225 tons	450 00	
		$1,596 36
Present valuation of flock:		
Breeding ewes, 141 @ $7.00	$987 00	
Yearling ewes, 56 @ $7.00	392 00	
Wethers, 34 @ $7.00	238 00	
Cull ewes, 9 @ $7.00	63 00	
Rams, 2 @ $37.50	75 00	
Lambs, 164 @ $6.00	984 00	
		$2,739 00
Valuation of flock July 1, 1917	$1,719 00	
Increased valuation		1,020 00
Receipts plus increased valuation:		
Receipts	1,596 36	
Increased valuation	1,020 00	
		$2,616 36
Total Costs:		
Feed, care, interest, etc.		2,410 29
Net profit		$206 07

While the above statement shows a small profit of $206.07, it must be borne in the reader's mind that the present inflated prices are not credited to the sheep. Also that those prices are charged against them *in feed stuffs. If the flock had been credited with its present valuation*

the net profit would have been very near $2,000.00, even if the flock had been valued at $2,731.00 last year. The above statement looks very encouraging from the fact that a small profit was made when valuing the ewes at only $7.00 each. Today they are selling for about three times that amount. The gain of $206.07 is over and above the charge of 6% on the investment. Or, the receipts of $206.07 plus $337.14 gives us a return of $543.21 on the investment, when valuing the ewes at $7.00 and the lambs at only $6.00 each.

Yearling wethers are selling for about double the amount estimated, and lambs such as we have are worth from $8.00 to $10.00 each.

The cost of labor for carrying on experiments was included in the above. This item alone doubled the time and cost required for caring for the flock under ordinary methods.



PIGGERY

SWINE.

Investment:		
4 brood sows, July 1, 1917	$162 50	
1 boar	50 00	
Building	1,000 00	
		$1,212 50
Present Valuation:		
3 sows @ $50.00	$150 00	
10 pigs @ $15.00	150 00	
1 boar @ $60.00	60 00	
		360 00

Cost:		
Labor, 1 hour per day @ 25c	$91 25	
Skim milk, 5 gallons per day @ 4c	73 00	
Oats	45 28	
Corn	119 60	
Middlings	64 25	
Bran	08	
Grain	7 50	
Registration certificates	8 00	
		$ 408 96
Interest on investment	$30 00	
Total cost		438 96
Receipts:		
Sold 7 pigs	$120 40	
Credit on feed remaining	74 65	
Increased valuation	147 50	
Manure, 18 tons @ $1.26	22 68	
		$ 365 23
Loss		$ 73 73

The loss occurring in the swine department is due to the death of four head. They would have added about $150.00 to the receipts had they lived. Their death is thought to have been caused by being too closely confined on a cement floor in winter. Rheumatic symptoms developed in their legs and they were helpless. The writer believes that if the above hogs had lived the receipts and expenses would have been about the same.

A charge of only $30.00 interest was allowed on the investment because of only a small part of the building being used by the hogs.

Three boar pigs and two young sows were sent out from the Station for breeding purposes.

Because of the climatic conditions at the Chatham Station, which being unfavorable to the growing of corn, and because of the very high cost of feed, plus the freight charges, and labor and retail man's profit there has not been much stress used in pushing and developing of the swine industry. No doubt that much of this unfavorable condition can be eliminated, when the country becomes more settled and when the farmers raise more barley as a substitute for corn feed, and when advantage is taken of suitably fenced pastures during the summer season.

POULTRY.

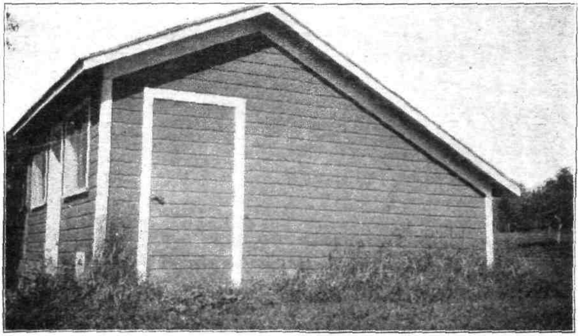
A little over one year ago all of the poultry on the place was sold and replaced by new strains of Barred Rocks and White Leghorns. The results obtained from the Barred Rocks are very good as the following table will illustrate.

Winter Egg Production:

Nov. 1st, to March 15th, inclusive, or 135 days:

	Total No. of Eggs.	Eggs per hen.	Per-centage.
Barred Rocks	775	70.45	52.19
White Leghorns	286	26	19.26

From this table it will be seen that the strain of Barred Rocks laid more than an egg every other day through the cold part of the winter. The winter was a very severe one, too. Many days in January and February the official thermometer registered several degrees below zero. The table also shows that the Barred Rocks averaged 2.7 times more eggs than the White Leghorns.



END VIEW OF POULTRY HOUSE

There were 11 hens of each breed. They were permitted to run together, in order that there would be no difference in environmental and feeding conditions.

It is thought that the cold winter conditions work more against the White Leghorns than the Barred Rocks because of their smaller size. The average egg production for the months of May and June, also indicate this to be true. The average egg production for the Barred Rocks for the month of May was 17 2/7 eggs each, for June 12 1/3 eggs each. The average production for the White Leghorns in May was 17.2 eggs each, and in June 16.9 eggs each. The average production was about the same for both breeds in May. In June, the average production was in favor of the White Leghorns by 4.57 eggs for each hen.

The hens were fed the following rations for winter and summer egg production:

Mash	*Oil meal*	25 lbs.	
	Corn meal	30 lbs.	
	Wheat bran	30 lbs.	
	Wheat shorts ...	15 lbs.	
	Salt	1 lb.	
Scratch feed	Corn	4 lbs.	
	Wheat	2 lbs.	For winter
	Oats	1 lb.	
	Corn	1 lb.	
	Wheat	2 lbs.	For summer
	Oats	4 lbs.	
	Corn	4 lbs.	
	Wheat	2 lbs.	For spring and fall
	Oats	2 lbs.	

The mash was kept dry in clean hoppers and the hens had free access *to it at all times. By handling it in this manner they never ate too* much. A mixture of scratch feed was fed to them twice a day. The amount given varied with the appetite of the hens. Usually they were fed one pint to each ten hens in the morning and a quart to the same number in the afternoon. The grain was thrown into the straw in winter and into the grass in summer, which rendered it necessary for the hens to work for their feed. Fresh water was provided in clean vessels. Oyster shell grit was placed ready for the hens at all times.

Skim milk was fed daily in a clean vessel as a substitute for meat. Rutabagas were fed daily as a substitute for green feed. Barley was fed in the place of corn many times. It was a good substitute.

FINANCIAL STATEMENT.

Investment:		
12 Barred Rocks	$24 00	
12 White Leghorns	24 00	
1 Barred Rock Rooster	4 00	
Building and equipment	325 00	
		$377 00
Present valuation:		
12 Barred Rocks	$24 00	
1 Barred Rock, rooster	4 00	
9 White Leghorns	18 00	
		46 00
Costs:		
Feed	$27 65	
Labor ¼ hour per day, or 91¼ hours @ 25c.	22 81	
Interest on investment	12 87	
Depreciation in flock 3 @ $2.00	6 00	
		$ 69 33

Receipts:		
Eggs	$77 47	
Chickens sold	6 37	
		83 84
Total receipts	$83 84	
Total costs	69 33	
Profit		$14 51

Twenty-seven dozen of Barred Rock eggs were sent into various counties in the Upper Peninsula for setting purposes. These were supplied both to Poultry Clubs and individuals at the rate of 50c per dozen. The object of sending them out at such a reasonable price was to get

SEEDED AMONG STUMPS FIVE YEARS AGO—NO BRUSH—STUMPS DECAYED—CLEARING INEXPENSIVE

as large a number of people interested as possible in raising poultry of superior qualifications. Also to prove the fact that a small flock of good chickens rightly handled is a good economic investment on the farm.

HORSES.

On July 1, 1917, the Station owned eight head of horses. Three head were sold off in the fall. The other five kept, came through the year in very good condition.

FINANCIAL STATEMENT OF THE COST OF KEEPING.

Feed:		
Bran	$52 30	
Oats	296 73	
Corn	434 10	
Hay, 22 tons @ $20	440 00	
Hay	29 00	
		$1,252 13

Other costs:		
Veterinary charges	$24 00	
Shoeing	43 00	
Bedding	40 50	
Medicines	4 50	
Miscellaneous	10 68	
		122 68
Total cost not including labor		$1,374 81
Receipts:		
3 horses sold	$550 00	
1 colt sold in spring	125 00	
		$675 00
Credit on remaining feeds:		
Hay, 2 tons	$ 40 00	
Grain	250 00	
Bedding	25 71	
Miscellaneous	8 20	
		323 91
Total cost		$1,050 90

LAND CLEARING.

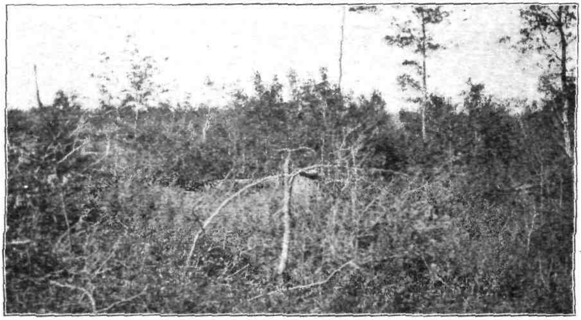
Land clearing has been going on quite rapidly on the Station farm. In the summer and fall of 1916, 235 acres were cleared of second growth and slashings. In doing this work a strip about 20 to 30 rods wide was cleared around the entire piece, and burned at favorable times, to help keep the fire under control. After this strip was entirely cleared, men were put to setting fires over the entire inclosed tract, at such times when it was very dry and the wind strong. Fire did much of the clearing and reduced the labor cost fully one-half. It cost $946.68 to clear the entire tract of slashings and second growth, or an average cost of $4.02 per acre.

SEEDING.

This tract was seeded in May, 1917, with the following mixture and with the following proportions respectively: Alfalfa 2 pounds, Mammoth Clover 2 pounds, June Clover 2 pounds, Timothy 4 pounds, at the rate of 10 pounds per acre. It cost $439.00 to seed this entire tract, or $1.87 per acre. The seed was scattered broadcast among the stumps with an ordinary hand seeder. The soil was not prepared in any way, nor was the seed harrowed in. It was just thrown on and washed into the soil by the rain. The seeding that developed was fairly good. After one year of reseeding, it will furnish excellent pasture and hay.

All of the different seeds are well represented. It is planned to pasture this new seeding for a period of four or five years before plowing. At the end of this time, all of the small brush will have been killed and the stumps mostly rotted, which will again reduce the cost of clearing of stumps to a minimum.

An area of over 40 acres was cleared of stumps this spring. This tract had been pastured by sheep and cattle for a period of five years. The green brush was entirely killed out. The roots and trunks of all of the stumps were well rotted. Five acres of this tract was measured off and cleared separately for the purpose of ascertaining the exact cost

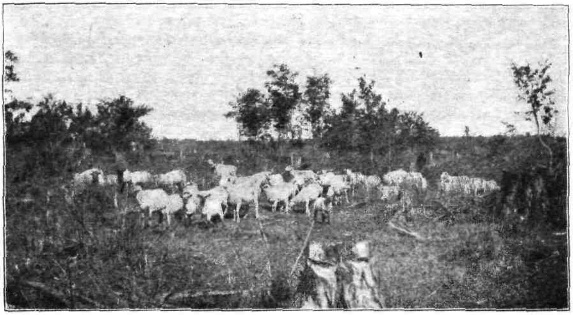


BEFORE GRAZING AND BROWSING BY SHEEP

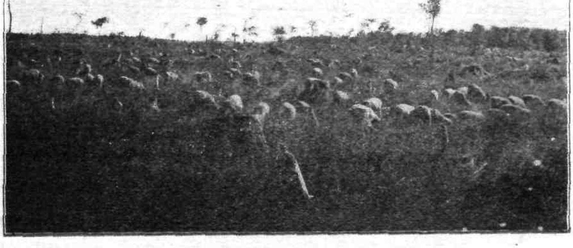
of removing the stumps. Following is an accurate account of same including cost of plowing per acre.

Dynamite, 124 lbs. at $18.75 cwt.	$23 29	
Fuse, 365 @ 70c cwt.	2 58	
Caps, 253 @ $1.45 cwt.	3 69	
Man, hours 110.5 @ 25c	27 62	
Team, hours 35 @ 25c	8 25	
Total cost of removing stumps		$65 43
Average cost per acre		13 08
Average cost of first plowing per acre, one team and one man 12 hours		6 00
Total cost per acre		$19 08
Cost of clearing of second growth per acre.		4 02
Cost of seeding per acre		1 87
Total cost of all per acre		$24 97

This data shows that, even under these conditions, it will cost approximately $25.00 per acre to clear cut-over land of hardwood stumps, brush and slashings. It is impossible to say definitely how much it would cost to clear land of slashings and green stumps immediately



AFTER GRAZING AND BROWSING



STATION SHEEP ON CUT OVER LAND

after the timber has been removed. As near as I can estimate the cost, as taken from the words of small farmers and settlers, it would be between \$75.00 and \$150.00 per acre.

A summary of my arguments for the land clearing policy pursued on the Station are: First, after spending the small sum of \$4.02 per acre on cut-over land and \$1.87 per acre for seed, we had it in shape to raise its first good crop—pasture. Second, this crop of pasture would support from two to three sheep per acre one year from date of seeding and about 4 to 6 thereafter. Third, that, while being pastured by livestock, the soil fertility is improving and the green sprouts are being killed, causing the stumps to rot. Fourth, that while sheep are helping to clear and improve the land, they are, at the same time, turning money over to the owner which will help support him and clear the land of its remaining stumps at the least possible cost.

Note.—This applies only to hardwood. Softwood stumps will not decay so quickly.

SOME GENERAL INFORMATION ON LIME AND ITS USES AND FUNCTIONS IN SOILS.

Special Bulletin No. 91

M. M. MCCOOL AND C. E. MILLAR.

Introduction.

Lime was used more than three thousand years ago in parts of Europe to improve soils. In some of our eastern states liming has been practiced since the earlier stages of the agricultural development and its use has gradually spread until it is added to the soil to a greater or less extent as far westward as the regions of lighter precipitation. Moreover, its need is quite generally recognized in several of the older settled regions west of the Cascade Mountains. In reality all lands in the humid regions will sooner or later become deficient in lime since it is constantly removed from the soil by water that passes through it, and by crops taken away.

The amount of lime applied to the soil in Michigan is steadily increasing from year to year. Although our laboratory and field investigators have not progressed far enough to make possible accurate statements concerning the deficiency of lime in Michigan soils, it is conservative to estimate that the majority of them are in need of it, especially the older fields. Moreover, these studies show that this condition is not confined to any particular class of soil such as sands, loams and clays and mucks, but is more or less common to all, yet the fact should not be overlooked that calcareous formations or those high in lime occur in all classes of soil.

The lime requirement for maximum returns on the investment varies greatly. Many fields require only small quantities in order to obtain satisfactory results from clover and alfalfa, while medium to very large amounts must be applied to others to establish these crops and produce suitable yields of many others.

FUNCTIONS OF LIME.

The benefits derived from applications of lime are the results of changes induced in the soil that make them more suitable for plant growth. Some of the functions that lime performs are very general in their occurrence, while others are more specific, being confined to a limited number of soils. Inasmuch as several or all of the effects of liming may be operative at the same time it is indeed complex, and therefore variable results from its use are to be expected. The various functions that lime may perform in the soil may be conveniently grouped as follows:

1. Modification of soil structure or tilth.
2. Neutralization of acids and other injurious substances.
3. Meeting the silicate requirements.

4. Effect upon the availability of minerals.
5. Increase the rate of decay of vegetable matter.
6. Increase the efficiency of fertilizers and manures.
7. Supply needed lime to plants.

Improvement of the Physical Condition of the Soil. It was formerly assumed that the chief reason for adding lime to the soil was to improve its physical condition or tilth due to its granulating effect upon the fine particles. It is recognized that heavy, compacted soils may be somewhat improved in this respect by liming, but this action is less general in occurrence and also less important than others.

Neutralization of Acids and Other Substances Injurious to Plants. Some poorly drained soils as well as some that contain very large quantities of vegetable matter such as peats and mucks carry acids in their soil moisture. These may be injurious to plants, the extent of the inhibitive effect depending upon the amount present. Although adequate drainage may improve many such soils liming is effective inasmuch as lime neutralizes these acids. Moreover, other injurious substances which occur in some soils may be counteracted by adequate applications of lime.

Meeting the Silicate Requirements. One of the chief effects to be gained from liming the majority of mineral soils is to supply the silicates with lime. It is known that the loss of lime from the soil leaves the silicate compounds, which compose the major portion of the mineral constituents of the soil, deficient in lime. This condition is detrimental to plants and is popularly spoken of as soil acidity or sourness of soils.

Effect Upon the Availability of Minerals. Lime may increase the availability of mineral plant food in some soils. This action of lime has long been held to be a very general and also a very important one, special emphasis having been placed upon the liberation of phosphorus and potash to the plants, but recent investigations indicate that undue emphasis has been placed upon this action, it being negligible with some soils.

Increase the Rate of Decay of Vegetable Matter. It is well known that the presence of sufficient amounts of lime in the soil results in a more rapid decay of vegetable matter as evidenced by the dark green color of various crops growing on limed land as well as the slightly delayed maturity in some cases. Moreover, the amount of nitrogen in the roots, tops and seeds of crops may be increased by the addition of lime to the soil. Such changes in the composition of the crops of course show that the available nitrogen in the soil is increased by lime and involve the soil bacteria. It is obvious that the free use of lime on the soil without suitable crop rotation and constant renewal of the vegetable matter content by means of stable manure, crop residues, and catch crops will result disastrously. On the other hand, if these precautions are taken the lime will be instrumental in maintaining the vegetable content due to the increased crop production. In some soils, more frequently in muck than others, the root development of crops is retarded, being

confined to the surface layers of soil until lime is added and worked deeply into the soil. Futhermore, the presence of lime in the soil is favorable for the development of bacteria that enter the roots of leguminous crops resulting in the fixation in the plants of nitrogen from the soil atmosphere. Organisms that are able in the absence of legumes, to remove nitrogen from the air and make it available to plants are likewise benefited by lime. It is probable that the amount of nitrogen so made available is small, yet it seems to be worthy of consideration.

Lime Increases the Efficiency of Fertilizers and Manures. Experience teaches that maximum returns from commercial fertilizers, stable and green manures are not obtained when there exists one or more adverse conditions such as poor drainage, deficiency of water in the soil, poor tilth, or lack of lime. It is unquestionably true that applications of lime to many of our soils long under cultivation as well as some of the newer ones should precede that of fertilizers. If this were done a more economical use of stable and green manures would result.

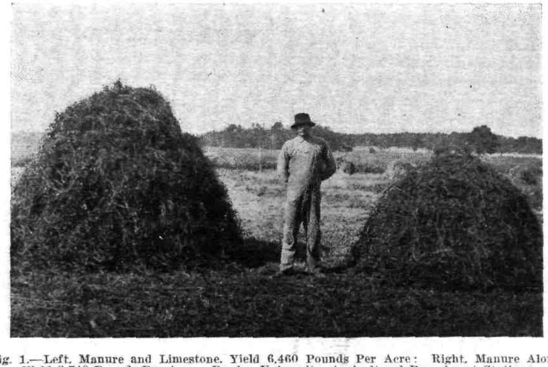


Fig. 1.—Left, Manure and Limestone. Yield 6,460 Pounds Per Acre: Right, Manure Alone, Yield 3,740 Pounds Per Acre.—Purdue University, Agricultural Experiment Station.

Some soils do not contain sufficient lime to meet the needs of the crops grown. There is an appreciable amount of evidence, contrary to past assumptions, that the use of lime on some soils results beneficially because it is needed in plant nutrition, especially is this the case with such crops as clover or alfalfa, or those that remove large quantities from the soil.

FORMS OF LIME.

Lime is placed on the market in three forms, namely, the oxide, the hydrate and the carbonate.

These different forms are often given a variety of names. The oxide

is known as quick lime, burnt lime, stone lime, caustic lime, lump lime, unslaked lime and building lime. The hydrated lime also is called slaked lime. The carbonate is the form of lime found in ground limestone and marl and also occurs in air slaked lime.

The term "agricultural lime" may be applied to any of the above forms and refers to lime sold for agricultural purposes but unfortunately not necessarily to a product especially well adapted for application to the soil.

When high grade limestone is burned in a kiln, 100 pounds of the dry stone gives off approximately 44 pounds of carbon dioxide gas, leaving about 56 pounds of lime oxide or quick lime. When 56 pounds of quick lime is moistened it takes up 18 pounds of water and forms 74 pounds of slaked lime or hydrated lime. It is evident then that 56 pounds of quick lime, 74 pounds of hydrated lime and 100 pounds of limestone or lime carbonate have the same power to satisfy the needs of the soil. However, some of these forms are much more soluble than others and consequently react with the soil much more quickly and in consequence we do not use these materials in these proportions in the field.

SOURCES OF LIME.

Michigan is fortunate in possessing two inexhaustible sources of lime, her limestone deposits and marl beds.

Limestone. At present there are in the State about forty-seven limestone quarries. The majority of these are located in the Upper Peninsula and northern part of the lower peninsula. There is a group of quarries in the extreme southeastern part of the State and an occasional quarry is found along the eastern coast and at other points throughout the commonwealth.

These quarries produce stone for a great variety of purposes, only a small portion of their output being used in agriculture. Some of the quarries turn out only a coarsely ground rock containing small amounts of fine material, while others furnish a very finely ground high grade rock. The limestone from the Michigan quarries are quite variable in composition some containing 96 to 97 per cent of calcium carbonate with only a trace of magnesium carbonate, while others carry as much as 44 or 45 per cent of magnesium carbonate.

Marl. There occur thoughout the State many beds of marl varying from low to very high grade. The lime is present in the marl as carbonate and hence supplies calcium to the soil in the same form as ground limestone. In addition to lime carbonate some marls contain varying amounts of magnesium carbonate, which also meets the "lime requirement" of the soil. The value of marl then, depends on the amount of calcium and magnesium carbonates it contains. A marl carrying 90 percent or more of these carbonates is considered to be of very high grade.

Occurrence of Marl. Marl is frequently found underlying areas of muck and peat and also along the shores and in the beds of lakes. In some instances the marl is covered by a few inches of muck while in others

it lies beneath several feet of it. The thickness of the beds or deposits is also quite variable. The marl owes its existence to lime that was washed out of the surrounding soil and deposited in lakes and to the accumulation of shells of lower animals such as the mollusca.

As it occurs in the beds, marl is generally a pasty mass varying in color from light to dark-gray depending upon the impurities present. Upon drying it becomes lighter in color and is easily crumbled, or broken up. If a small amount is placed in half a tumbler of strong vinegar or weakened muriatic acid it will give off bubbles of gas and go into solution. This is one method of identifying marl as well as roughly estimating its purity. Some deposits are filled with small shells which aid in identifying this material.

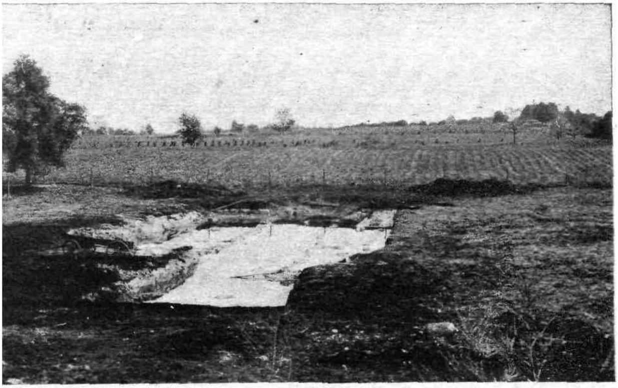


Figure 2. An Easily Accessible Marl Bed.

A more general utilization of Michigan's marl deposits for agricultural purposes is desirable.

Water Content and Weight of Marl. When marl is thrown out of the bed and allowed to drain the amount of moisture retained is quite variable and depends somewhat on the amount of impurities. In general the purer the marl the less water it will hold but sandy marls contain less water than clay marls. The following table shows the water content, the weight of a cubic yard and the weight of lime carbonate contained in a cubic yard of several Michigan marls.

Table 1.—WATER CONTENT AND WEIGHT OF MARL.

Sample Number.	Per cent. of Carbonates.	Per cent. of H_2O on dry basis.	Per cent. of H_2O on wet basis.	Weight of cubic yard dry, in pounds.	Weight of cubic yard of wet *Marl, in* pounds.	Weight of Lime Carbonate in 1 cubic yard dry marl.	Wt. of Lime Carbonate in 1 cubic yard of wet marl.
1	75	46.7	32	1652	2430	1239	1239
2	85	45.5	31.3	1665	2424	1415	1415
3	88	38.9	28	1670	2319	1470	1470
4	95	35.1	26	1731	2339	1644	1644

Sugar Factory Lime. Lime is used by sugar factories to clarify and purify the juice and since impurities cause trouble later in the process of refining a very high grade of lime is used. Milk of lime is added to the vats of juice and then carbon dioxide is run in to precipitate the lime as lime carbonate. This is later filtered out and discarded. This material contains a small amount of organic matter from the beet juice but otherwise is a very pure carbonate of lime and is admirable material for applying to the soil. It can generally be purchased at a low cost since it is simply a waste product. It very often contains water and hence it should be bought by the yard rather than by the ton since a cubic yard will contain about the same amount of lime carbonate whether the material is wet or dry.

There is another form of lime which may occasionally be obtained from sugar factories. This is the cleanings from the kiln. Many of the factories prefer to burn their own lime and when the kilns are cleaned a quantity of impure burnt lime or stone lime is obtained. This material is variable in composition but is mostly quick lime when fresh; after standing a short time it contains a large amount of hydrated lime.

Wood Ashes. In some localities wood ashes may be obtained in sufficient quantities to apply to the soil. Ordinarily wood ashes contain from 20 to 50 per cent of lime expressed as quick lime but they are usually applied to the soil as a source of potash.

Lime from Acetone and Alkali Works. There are in the State various acetone and alkali works which turn out lime as a by-product. This material is usually of high grade, its chief drawback being a high-water content if exposed to the elements. When it can be obtained near at hand and at a low price it is sometimes more advisable to use such products than to buy the more expensive forms of lime. The cost of transportation and difficulty in distribution must be taken into consideration when figuring the cost.

CHANGES LIME UNDERGOES WHEN ADDED TO THE SOIL.

When the various forms of lime are added to the soil their composition is altered. The change that is now considered to be most desirable

is the union of the lime and silicates to form calcium silicates or the correction of so-called soil acidity. When hydrated lime is added to the soil some of it goes to form air-slaked lime or the carbonate and some the calcium silicate. Now, the lime or magnesium carbonate thus formed or added to the soil as marl or ground limestone likewise passes to the silicates.

It is now understood that the immediate efficiency of the various forms of lime is dependent upon the rate at which they pass over to the silicate. The hydrate is quite rapid and the carbonates are governed mainly by their mechanical state or the size of their particles as well

Figure 3. The More Finely Ground Limestone Reacts More Quickly With the Soil.

1. No Lime. 2. Lime requirement as 10-20 mesh limestone. 3. Lime requirement as 40-60 mesh limestone. 4. Lime requirement as 60-80 mesh limestone. 5. Lime requirement as marl.

as the thoroughness of mixing with the soil mass. Particles of limestone approximating 1/100 of an inch in diameter or so-called 100 mesh lime are about as rapid in correcting soil acidity as the hydrate or 2,000 pounds of it approximates 1,500 pounds of the hydrate in this respect, as exemplified by table II.

TABLE II.—EFFECT OF FORMS AND FINENESS OF LIME ON THE YIELDS OF RYE ON CASS COUNTY EXPERIMENTAL PLOTS. SANDY SOIL. 1918.

Treatment.	Bushels per *acre.*
Hydrated lime and acid phosphate and nitrate of soda	21.60
Marl and acid phosphate and nitrate of soda	18.40
Limestone passing 80 mesh screen, and acid phosphate and nitrate of soda	21.28
Limestone, 40-60 mesh, and acid phosphate and nitrate of soda	18.36
Limestone, 10-20 mesh, and acid phosphate and nitrate of soda	14.40
No treatment	12.82

Some limestone deposits contain calcium or lime carbonate, and also magnesium carbonate. If the amount of the latter is rather high they are popularly spoken of as magnesium limestones. The larger particles of magnesium limestones are somewhat slower in their action than the non-magnesium limestones as illustrated by results reported by the

Pennsylvania Agricultural Experiment Station in Table III. In these studies equal quantities of a given soil were treated with the same amount of magnesian and non-magnesian limestones, the particles of which ranged in size from coarse to very fine. After a period of three years the comparative rate of change, or the efficiency of these in meeting the soil's requirement was ascertained by chemical means. According to these results if the particles are very fine the difference in the rate of transformation is negligible.

TABLE III.—COMPARATIVE RATE OF TRANSFORMATION OF LIMESTONE IN THE SOIL.

Per cent. of total carbonates not recovered after three years.

	Non-magnesium Limestone.	Magnesium Limestone.
100 mesh limestone	92.4	91.2
60 mesh limestone	81.5	72.2
20 mesh limestone	46.7	34.9
8 mesh limestone	14.9	5.97

If the lime is not mixed with the soil mass, of course, its efficiency is somewhat impaired. Inasmuch as the individual particles of marl are very minute its immediate effectiveness is governed largely by the condition in which it goes into the soil. If lumpy, naturally larger quantities are required to bring about a given result than if it is more or less disintegrated. As it usually goes on the land, about 2½ to 3 cubic yards of 95% marl are required to equal 1,500 pounds of the hydrate and 2,000 pounds of the powdered limestone respectively. This ratio decreases the second year inasmuch as the lumps are broken down by freezing and changes in the water content.

CROPS BENEFITED BY LIME.

The response of our cultivated plants to lime is variable some being more tolerant of a deficiency in the soil than others. Reports on record show that some crops will thrive on a given soil without application of lime and others will not, while some soils are so low in lime that they are practically barren of plant growth. Thus, in discussing the response of different crops to lime it is essential that the condition of the soil with respect to this substance be considered. Some of the field crops that are known to respond to lime are as follows:

Legumes	*Non-legumes*	
Alfalfa	Corn	Potatoes
Sweet clover	Oats	Carrots
Crimson clover	Wheat	Turnips
Mammoth clover	Barley	Cucumbers
June clover	Rye	Cantaloupes
Alsike clover	Timothy	Pumpkin
Soy beans	Buckwheat	Tobacco
Cow peas	Sorghum	Cabbage
Beans	Beets	
Vetch		

Where soils are low in lime the following vegetables are known to respond to its use: Pepper, parsnips, salsify, squash, spinach, red beet, celery, cauliflower, lettuce, and onion. Many plants grown for their blossoms also respond to lime.

SOME RESULTS FROM THE USE OF LIME.

Lime may be utilized with ample margin of profit on so-called sour soils. Experiment station workers in many states by means of well-planned and carefully conducted field trials have shown conclusively that the use of lime on such soils is sound practice. For example, Thorne and co-workers of the Ohio Agricultural Experiment Station have made many valuable contributions to our knowledge of the lime relationships of soils and crops.

Wiancko and others, of the Indiana Agricultural Experiment Station report that three-fourths of the soils in the State are in need of lime. Where ground limestone has been used on the experimental farms it has returned safe margins of profit.

The results of Illinois experiments, on soils deficient in lime, conducted by Hopkins and associates, show very strikingly that many soil must be liberally treated with lime before they can be permanently improved. Hopkins, (1912) in commenting upon the results of some 145 tests in six counties, states that the value of the increase has been about four times the cost of the regular application of two tons of limestone per acre every four years.

Whitson and associates of the University of Wisconsin, by means of many field experiments as well as laboratory investigations report that soils deficient in lime are quite common in Wisconsin and strongly recommend its use on such for their improvement.

Several experiment stations more remote from Michigan have made contributions to this subject, notably, Delaware, Maryland, New Jersey, Rhode Island, Massachusetts, Pennsylvania, Tennessee and Missouri.

Reports from several county agricultural agents and many farmers in different sections of Michigan, as well as results obtained from recently inaugurated field tests indicate that the use of lime on the majority of our soils is profitable.

Liming where needed increases the efficiency of fertilizers and stable manure. Many are the reports to the effect that commercial forms of plant food are unsatisfactory without lime. Some of our recently inaugurated field tests also show that lime may greatly increase the

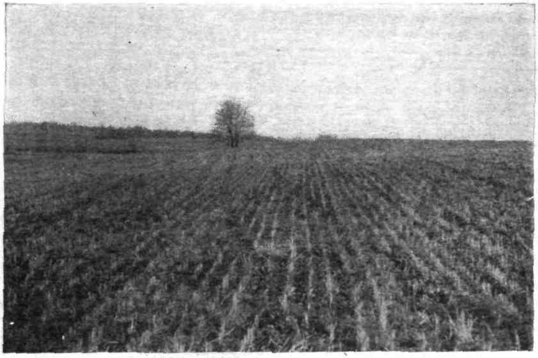
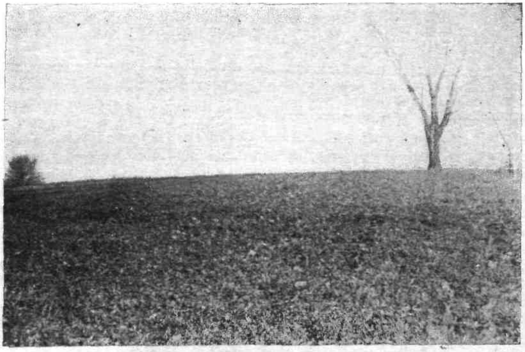


Figure 4a. Untreated Portion of Field.



Treated With Marl and Acid Phosphate.

Figure 4b. Lime and fertilizer often make possible fine stands of clover.

This Ingham county sandy soil has refused to grow profitable crops of clover for years, but when treated with marl and acid phosphate good catches are obtained. Compare with figure 4a.

value of other treatments, especially manure and phosphates when they are added singly or together to the soil. These results are in accord with those obtained from long continued trials in other states.

Figure 5. Oats and Other Grain Crops are Benefited by Liming.

On the left is seen the effect of treating a Van Buren county soil with manure and ground limestone. On the right, manure alone was used.

HOW TO DETERMINE IF A SOIL NEEDS LIME.

There is a general impression that a sample of soil may be taken into the laboratory and the exact amount of lime needed to correct its acidity determined. It is true that a number of methods have been outlined and extensively employed for this purpose and have doubtless yielded much valuable information. But as yet no method has been devised which enables one to determine how much lime it is most advantageous to use in the field. The results obtained for a given soil by different methods are quite variable and in consequence the lime requirement of the soil will depend somewhat on the analytical method employed.

There are, however, methods of determining whether or not a soil is in need of lime but which make no attempt to determine the exact amount that should be applied.

Perhaps the simplest of these methods is the litmus paper test. To make this test the soil is moistened with rainwater, and made into a ball. This is broken open and a strip of blue litmus paper inserted into the opening and the soil pressed firmly together around the paper. In about five minutes the paper is removed and examined. If the color is pink the soil is considered to be in need of lime. In making this test great care must be exercised to obtain a good grade of litmus paper. That obtained from the drug store is often not sufficiently sensitive to give satisfactory results. The paper should not be handled when the

fingers are moist with perspiration as this will redden it. Only soft water should be used to moisten the soil.

Treating the soil with muriatic acid and noting if bubbling occurs is recommended as a test for an excess of lime but not necessarily a deficiency of lime. No gas may be given off from a soil and yet the growth of crops on the soil may not be increased for several years by the use of lime.

The nature of the growth of plants on a soil is a good indication of its need of lime. Failure or poor growth of clover, alfalfa and sweet clover is very often due to lack of lime. A medium stand of these crops in many cases would have been much improved had lime been applied

Figure 6. Lime in the Soil is Essential to Good Stands of Sweet Clover and Alfalfa.

If this Kent county farmer had covered his field with marl he would have had an abundance of hay.

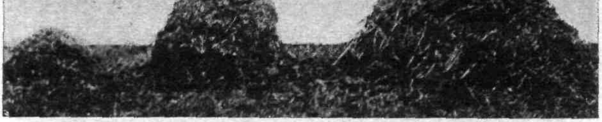
while preparing the ground before the seeding. Some plants such as sorrel are able to grow in soils deficient in lime, and hence subsist where more sensitive ones fail. For this reason the presence of much sorrel is considered an indication of a sour soil.

As pointed out on another page of this bulletin most farm crops are favored by the presence of an abundance of lime in the soils, the effect being especially noticeable on alfalfa and sweet clover. Consequently the most satisfactory method of determining the lime needs is to apply some form of lime in different amounts and carefully note the results obtained. If ground limestone is used the trial applications should vary in amount from one to three or four tons per acre. If the hydrate is employed strips of land should receive amounts ranging from one-fourth to one ton per acre.

HOW TO APPLY LIME.

Lime to be most effective must be thoroughly worked into the soil. A thorough incorporation with the soil mass results in the root system of the crops grown coming in contact with larger areas of limed soil. Powdered limestone, marl or hydrated lime should not be applied to wet soils, since the particles form small groups thus markedly slowing up their actions. Usually best results are obtained when lime is applied to the soil previous to forming the seed bed.

Machines may be employed for spreading lime. One type is attached to the wagon which carries the lime while the other runs on its own wheels as a separate machine. The latter is in most favor because it can be operated by one man and with less horse-power than is required to draw the farmer and the loaded wagon.



No Lime. Lime as Top-dressing in Spring After Seeding. Lime Harrowed in Before Seeding.

Figure 7. Timothy—Though Incorporation of Lime With the Soil is Essential for Maximum Results.

This type of machine may be purchased on the market or may be made by a blacksmith and carpenter. A complete description of the plans for making a spreader for ground limestone is presented in Illinois Agricultural Experiment Station Circular 110.

Although ground limestone and hydrated lime may be distributed from the wagon or heaps in the field by means of a shovel, it is usually advisable to employ a machine since its use results in a more uniform distribution when somewhat smaller applications are required.

If the caustic or stone lime is used it is generally advisable to place it in small heaps about the field and cover these with moist earth until slaked and then distributed by means of a shovel. If the lime is not too lumpy it may be distributed without this treatment.

Marl may be applied to the soil with a shovel, a manure spreader or if dry and sufficiently pulverized with a lime spreader. In the use of the manure spreader precaution should be taken to prevent overloading. Some apply marl and manure to the soil at the same operation where the heap of marl is accessible, thus saving an appreciable amount of labor.

Other methods of making more efficient use of labor may be employed. The limestone should be hauled at once thus releasing the car and avoiding demurrage. Arrangements should also be made to spread the

lime as it comes from the car thus saving the labor of a second handling. This can often be accomplished cooperatively, that is if neighbors order lime and assist each other in hauling and spreading it.

Where the lime is hauled two miles or less two men, a driver and two teams with three wagons and one lime spreader can take 20 to 30 tons from the car and spread it in two days. One man is kept in the car loading the lime into a wagon. The driver with one team hauls the loaded wagon to the field, leaves it, and takes an empty wagon back to the car and returns with another load. The other man remains in the field and spreads the lime. If the field is large the load may be hauled to the middle line of the field and the distributor filled at this point. Other labor saving plans that are suitable to local conditions doubtless can be worked out.

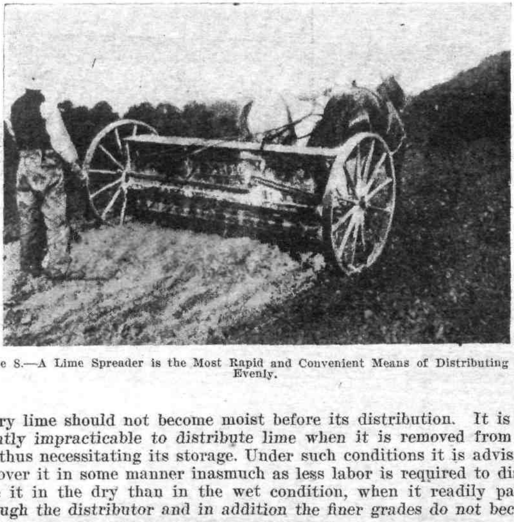


Figure 8.—A Lime Spreader is the Most Rapid and Convenient Means of Distributing Lime Evenly.

Dry lime should not become moist before its distribution. It is frequently impracticable to distribute lime when it is removed from the car thus necessitating its storage. Under such conditions it is advisable to cover it in some manner inasmuch as less labor is required to distribute it in the dry than in the wet condition, when it readily passes through the distributor and in addition the finer grades do not become lumpy.

If bags of lime are stored or piled in the field much labor may be saved by properly arranging the bags in the heaps. If the bags are stacked so that a maximum number may be taken from a higher plane and placed upon an adjacent lower plane an appreciable amount of labor may be saved in handling. This may be accomplished by erecting one heap to a convenient height, the thickness being the length of a sack. Joints should be formed at the ends in order to hold the bags in place.

A second heap is built parallel and adjacent to the first and to the same height. Then boards may be placed thereon and additions made to the first until a convenient height is again reached. Usually about eight feet is the most practicable height to attain. In removing the bags the reverse order from stacking should be followed.

Usually considerable time and labor is wasted when the lime is taken from the bag and placed in the lime spreader. A convenient scheme is to obtain a corn husking hook that can be fastened on the right hand; the bag is placed on the screen of the spreader on edge. By means of the hook an opening is made along the flat side and near the center, perpendicular to this slit and again near the center of the flat side of the bag another opening is made. The lime may readily be removed by turning the split side of the bag downward upon the screen.

Figure 9. Vetch Does Not Thrive on Many of the Light Soils Until They Have Been Limed. The Samples of Vetch Shown in This Figure Were Taken From Equal Areas of a Limed and Unlimed Sandy Soil.

WHEN TO APPLY LIME.

Since legumes are on the whole more sensitive to a lack of lime in the soil than other crops it is generally considered best to apply lime preceding these crops. When clover or alfalfa is to be seeded in wheat or rye the lime should be spread after plowing and worked into the soil when the seed bed is prepared. If the seeding is to be made with oats or barley the lime may be applied in the spring and worked into the soil. When alfalfa or sweet clover is seeded without a nurse crop the lime should be applied as soon as the ground is broken up so that it may become thoroughly worked into the soil by seeding time.

When vetch is seeded with rye the lime should be spread immediately after plowing. In case the land is not plowed for any of the above crops but is prepared with a disk or spring-tooth harrow, the lime should be applied before the soil is worked.

Limestone or marl may be added immediately before seeding or to growing crops without injury, but if caustic lime is used, it should be applied and incorporated with the soil at least ten days or two weeks before seeding, in order that its caustic properties may be dissipated before the seeds germinate, thus avoiding injury to the young plants.

Alfalfa may be top-dressed with the carbonate carrying compounds and where the alfalfa renovator or spring-tooth harrow is used the lime may be mixed with the soil to some extent. As a rule if the land is limed previous to this crop it will endure as long as the alfalfa is permitted to occupy the land. Reports are on record which show that permanent meadows and pastures growing on soils deficient in lime may be profitably top-dressed with this substance.

It is readily seen that one may apply lime under widely different conditions. Thus, there are opportunities for the consideration of this operation in relation to other farm work, condition of weather and the land.

Lime must be applied repeatedly to the soil. It has been shown by determining the amount of lime carried by river water, well water, and drainage water from tile, and large containers filled with soil and placed in the ground, that as a general rule much more of this substance is washed out of the soil than is removed by crops. Although the amount so lost has been shown to vary rather widely it is probable that 300 pounds per acre annually, closely approximates the losses under average conditions. At any rate it is now looked upon as being sound practice to lime the soil at least once in each four or five-year rotations. Further experience may show that small frequent applications of lime are most profitable on some soils.

Lime and Manure. Under some conditions lime and manure may be applied to the soil at the same time. Where the lime is in the form of the carbonate, namely, as marl, ground limestone, air slaked, sugar factory lime or that obtained from the manufacture of acetone, it may be mixed with the manure in the heap or stable or applied to the soil with it. In the light of our present knowledge the oxide and the hydrated lime should not come in contact with the manure and should precede its application to the soil ten days or two weeks.

SUMMARY.

Lime is needed by many soils to increase their crop-producing power. When applied to soils that are deficient in it lime may alter the structure, neutralize acids and other injurious substances, satisfy the silicates, in some cases make available mineral plant food elements, increase the rate of decay of vegetable matter, make manures and fertilizers more efficient and supply lime needed in the formation of plant food.

The principal forms of lime used in Michigan's agriculture are ground limestone, hydrated lime and marl.

There are two inexhaustible sources of lime in Michigan, the limestone deposits and marl beds. The utilization of many of the marl beds await the perfection of suitable mechanical apparatus for the removal of the marl.

The immediate efficiency of limestone depends in a large measure upon the fineness of the particles and thorough incorporation with the soil while that of marl depends upon its purity as well as thorough mixing with the soil. Hydrated lime usually acts quickly in the soil. On account of its greater solubility its incorporation with the soil mass is not so essential, as it tends to move about in the soil with the soil moisture. Especially is this the case with sandy soils and with the larger applications.

Although crops differ somewhat with respect to their lime requirements, it has been conclusively proved that if the soil is deficient in lime the common crops with few exceptions, respond to its use.

The margin of profit from normal applications of lime on so-called acid soils is safe, as has been demonstrated by many experiment station workers and farmers.

The efficiency of stable manures and fertilizers is increased by ample quantities of lime in the soil, conversely, stable manure and fertilizers increase that of lime.

The most economical or best amount of lime to apply to a given soil cannot be determined by laboratory methods, although its needs may be indicated by several. Field trials should always be conducted when one applies lime to the soil, this being nothing short of sound business methods.

Lime should be applied to the soil in the rotation as near as practicable to the crops that are most benefited by it especially if small applications are made. This coupled with the fact that thorough mixing with the soil is essential are the chief considerations in the application of lime to the soil. In some cases it is profitable to top dress alfalfa. Moreover, permanent meadows and pastures growing on soils deficient in lime may be top dressed to advantage.

CONCLUSION.

In view of the low lime content of many Michigan soils the losses entailed by leaching and by crops removed from the land and much evidence that its use is profitable, every farmer should satisfy himself by thorough field trials that his soil does or does not need this substance. There are many indications that lime, by establishing alfalfa and clover, as well as by its favorable effect on other crops is the most promising single substance the farmer has at his disposal for soil improvement.

Although many facts have been established concerning the liming of soils it is unquestionably true that our knowledge of several phases is meagre, especially is this true of sandy and muck soils. The question as to the most economical fineness of grinding limestone is one that cannot be satisfactorily answered. Moreover, the forms, fineness and size of applications for different soil classes are worthy of serious consideration.

Finally, lime should be looked upon as only one of the conditions involved in permanent systems of soil fertility. Since its presence in the soil results in a somewhat more rapid decay of vegetable matter precautions must be taken by means of crop rotation, turning under crop residues and manure to maintain this substance which is so vital to soil productivity.

FEEDING VALUE OF SKIM MILK FOR SWINE

Special Bulletin No. 92

BY H. W. NORTON, JR.

It is estimated that 1,669,836,000 pounds of skim milk and 238,-548,000 pounds of buttermilk were produced in Michigan during the year 1917, as by-products of the butter industry. Large amounts of these by-products are consumed as human foods in one form or another but immense quantities are left to be disposed of in other ways, principally as feed for calves, pigs and poultry. The value of skim milk for feeding purposes will depend upon a number of factors, such as the varieties and proportions of other feeds used in combination with it, condition of the milk when fed and the age of the animals consuming it, but with the high prices at which feeds are selling on the market at the present time, a much higher value can be placed upon skim milk than feeders have generally attributed to it. Considerable discussion is heard among farmers and dairymen on this subject and numerous inquiries have been sent in to the Experiment Station regarding the value of dairy by-products under present conditions. This circular gives a brief discussion of these problems and summarizes the results of experimental work along this line at several of the Experiment Stations, (Cornell, Indiana, Iowa, Michigan, Missouri, Nebraska, Ohio, Wisconsin, and Ontario.)

COMPOSITION OF DAIRY BY-PRODUCTS.

The following table from "Feeds and Feeding", by Henry and Morrison, shows the nutrients contained in 100 pounds each of whole milk, skim milk, buttermilk, and whey.

	Dry matter in 100 lbs.	Digestible Nutrients in 100 lbs.			Nutritive ratio.
		Protein.	Carbohydrates	Fat.	
Whole Milk	13.6	3.3	4.9	4.3	1:4.4
Skim milk	9.9	3.6	5.1	0.2	1:1.5
Butter milk	9.4	3.4	4.9	0.1	1:1.5
Whey	6.6	0.8	4.7	0.3	1:6.8

The table shows that skim milk differs from whole milk only in fat content and that it is a very highly nitrogenous feed, having a nutritive ratio of 1:1.5 while whole milk is 1:4.4. As whole milk is the natural milk for calves and pigs, it is readily seen that the best results can be secured by feeding skim milk only when it is used in combination with other feeds such as corn, wheat, oats, rye or barley, which will furnish an abundance of carbohydrates and fat, so as to properly balance it. Corn, which is ordinarily our most abundant fattening food, has proven to give the best results of all grains which are commonly fed in conjunction

with skim milk to swine. The high protein and ash content of skim milk makes it especially valuable for the young animal for the development of bone and muscular tissue and on account of the rapidity and ease with which skim milk is digested it is particularly adapted to the very young animal whose digestive system is not capable of handling the majority of feeds. The fact that the dry matter of skim milk is practically 100% digestible accounts largely for its remarkable feeding value when compared with grain feeds. While the latter contain a much higher per cent dry matter, more energy must be expended by the animal in digesting it and a considerable proportion is undigestible and wasted.

CONDITION OF MILK.

The best results are secured when care is taken to have the milk of uniform quality when fed. With young calves it is of utmost importance to have the milk fed at about body temperature as cold milk will surely derange the digestive functions and result in scours. Whenever possible it is best to use the milk direct from the separator and while still warm. If the milk is to be fed sour, it should not be too old as various bacterial organisms are present and may cause trouble. Whether sweet or sour a uniform quality will be most satisfactory. Experiments at this station in feeding sweet and sour skim milk to pigs, resulted in a favorable showing for the sweet milk, 100 pounds gain in live weight requiring 98 pounds less milk and 15 pounds less grain, than when sour skim milk was fed. In these trials both lots were fed a grain mixture of equal parts corn meal and ground wheat in proportion of 7.5 pounds milk to one pound grain, the only difference being in the milk which was fed sweet to one lot and sour to the other. In other feeding trials there has been very little, if any, difference resulting from feeding sweet or sour skim milk and this point is generally considered a matter of minor importance.

SKIM MILK FED ALONE.

Very little data is available on this question but trials at this station would indicate that skim milk may be fed to pigs as the entire ration with satisfactory results. 15 pigs in two lots were fed for four weeks on sweet skim milk alone. One lot averaged 103 pounds each and the other lot 32 pounds each at the beginning of the test. In these trials 2150 pounds skim milk produced 100 pounds gain, a very favorable showing for skim milk.

SKIM MILK AS A SUPPLEMENT TO CEREAL GRAINS.

For pig feeding, nothing combines with corn to give more satisfactory results than skim milk. This combination makes a most palatable ration for the pig, resulting as a rule in a heavier consumption of feed and more rapid gains than from any other ration. All of the cereal grains, such as wheat, rye, barley and particularly corn, are comparatively low in protein and will give better results when fed in combination with some nitrogenous feed, such as skim milk, than when fed alone or in conjunction with other rich carbohydrate feeds. With a view toward determining the value of skim milk as a supplement to corn and other cereal grains when fed to pigs, a large number of feeding trials from Experiment Stations throughout the country have been summarized as follows: 415 pigs, fed

cereal grains only (corn, wheat, rye and barley included), made an average gain of 100 pounds from 486.5 pounds of grain. 325 pigs, fed cereal grains (corn, wheat, rye and barley included) supplemented by skim milk, made an average gain of 100 pounds from 266.9 pounds grain and 785.1 pounds skim milk.

By comparing these two lots of pigs, it will be seen that the use of 785.1 pounds of skim milk resulted in a saving of 219.6 pounds of grain, or *100 pounds skim milk replaced 28 pounds of grain.*

The following table shows the value of skim milk as a supplement to corn and the other cereal grains and is based on the figures derived from the summaries given above, which include 415 pigs fed on cereal grains alone and 325 pigs fed cereal grains supplemented with skim milk.

Value of Skim Milk as a supplement to Cereal Grains for Pigs.

When price of grain per cwt. is	100 lbs. of skim milk as a Supplement is worth	When price of grain per cwt. is	100 lbs. of skim milk as a supplement is worth
$1 00	$0 28	$2 75	$0 77
1 25	35	3 00	84
1 50	42	3 25	91
1 75	49	3 50	98
2 00	56	3 75	1 05
2 25	63	4 00	1 12
2 50	70	4 25	1 19

This table shows that when cereal grains range in price from $50 to $80 per ton, as has been the case during the winter of 1917-1918, skim milk ranges from 70 cents to $1.20 per cwt. in value as a supplementary feed.

AGE AS A FACTOR.

The value of skim milk as a supplement will vary considerably depending upon the age of the animal fed. With young growing animals the protein requirement is higher than with mature animals during the fattening period, and hence skim milk would have a higher value when fed in combination with grain to growing pigs than when fed to fattening hogs.

An examination of the data in connection with the 325 pigs mentioned above as fed on cereal grains and skim milk, shows that 200 of these pigs weighed less than 100 pounds each when the tests started and the remaining 125 weighed 100 pounds each or more. Grouping them according to weight and comparing with pigs of similar weight fed cereal grains only, shows the following:

Total No. pigs included.	Range in weights.	*Feed consumed per 100 pounds gain* Grain.	Skim milk.	Grain saved per 100 pounds milk fed.
162	30–100	468.9		
200	28–100	257.0	750.4	28.2
253	100–248	495.5		
125	100–231	284.1	845.2	24.9

Thus pigs under 100 pounds weight, when fed cereal grains alone, required 468.9 pounds grain per 100 pounds of gain, while on a ration of skim milk and grain, 257 pounds of grain and 750.4 pounds of skim milk produced 100 pounds of gain. Therefore 750.4 pounds of skim milk replaced 211.9 pounds grain, or 100 pounds skim milk replaced 28.2 pounds grain. With the older and heavier weight pigs, 100 pounds skim milk replaced 24.9 pounds grain. Hence, in these comparisons, skim milk showed 13.2% greater value when used to supplement grain in the ration of the young growing pig than with the more mature and heavier weight hogs.

PROPORTION OF MILK TO GRAIN.

Another factor influencing the value of skim milk as a supplement to grain is the proportion of milk to grain in the ration used. It is generally conceded that skim milk will give greatest returns as a supplement to cereal grains when not more than three pounds milk are fed per pound of grain. An examination of the above mentioned experiments on this point is interesting. All the feeding trials were divided into two groups, placing in one group all those in which the proportion of milk to grain in the ration was not more than three to one, and placing in the other group all those in which the ration consisted of more than three pounds milk to one pound of grain.

Total No. of pigs included.	Average proportion of skim milk to grain.	Feed consumed per 100 lbs. gain.		Grain saved per 100 pounds milk fed.
		Cereal grains.	Skim milk.	
415		486.5		
186	1.7 lbs.: 1 lb.	289.8	516.7	38 lbs.
139	5.6 lbs.: 1 lb.	225.5	1271.2	20.5 lbs.

The group which received the rations in which the proportion was not more than three pounds skim milk to one pound grain, averaging less than 2 to 1, showed a saving of 38 pounds grain per 100 pounds milk fed while those fed a larger proportion of milk to grain, averaging 5.6 pounds skim milk to one pound grain, showed a saving of only 20.5 pounds grain per 100 pounds milk consumed. Hence, in the first group, where less than two pounds of milk was fed per pound of grain consumed, skim milk showed 85.3% higher feeding value than in the second group when nearly six pounds of milk was fed per pound of grain consumed. This is a matter of considerable importance when the supply of skim milk is limited or must be purchased but would be of no practical significance when large quantities were available.

COMPARATIVE VALUE OF SKIM MILK AND OTHER NITROGENOUS FEEDS.

The above figures give the value of skim milk as a supplement to corn and other cereal grains and indicate that when this by-product of the dairy is available it can be combined to excellent advantage with the farm grown grains for pig feeding. When skim milk is not available, as on the farm where whole milk is sold for the retail trade or for condensing

purposes, it becomes necessary, if the best results are to be secured to purchase it or some other protein feed to combine with the cereal grains for feeding pigs. Tankage, middlings and oil meal are the feeds most commonly used in place of skim milk for feeding pigs and in order that a comparison of these different supplements may be made, a large number of feeding trials from different Experiment Stations have been summarized in the following table. These tests included pigs of various weights and ages fed on cereal grains (including corn, wheat, rye and barley) with some one of the above mentioned nitrogenous supplements, and are grouped here accordingly. The last group, where soy beans were used as a supplement, represents only 29 pigs, so that these results would not be as reliable as in the other cases where data was available from a larger number of feeding trials.

VALUE OF SKIM MILK AS COMPARED TO OTHER NITROGENOUS SUPPLEMENTS TO CEREAL GRAINS.

Number of pigs included.	Feed consumed per 100 pounds gain						Grain replaced by 100 lbs. of supplement.
	Cereal grain.	Skim milk.	Tankage.	Mid-lings.	Oil meal.	Soy bean meal.	
415	486.5						
325	266.9	785.1					28.0
332	379.3		42.5				252.5
130	283.3	....	....	191.2			105.2
106	377.3				51.7		261.7
29	308.3					68.1	300.0

By comparing the first two lots in the table we find that 486.5 pound grain was required to produce 100 pounds gain and that 266.9 pound grain supplemented by 785.1 pounds skim milk produced 100 pounds gain Therefore, 785.1 pounds skim milk replaced 219.6 pounds grain or 357. pounds skim milk replaced 100 pounds grain. With the tankage fed lot 379.3 pounds grain supplemented by 42.5 pounds tankage produced 10 pounds gain.

Therefore 42.5 pounds tankage replaced 107.2 pounds grain
or 39.6 pounds tankage replaced 100 pounds grain.
In like manner 95 pounds middlings replaced 100 pounds grain
38.2 pounds oil meal replaced 100 pounds grain
33.3 pounds soy bean meal replaced 100 pounds grain

Comparing these values with the replacement value of skim milk whe used as a supplement to corn and other cereal grain,

1 pound tankage is equivalent to 9 pounds skim milk
1 pound middlings is equivalent to 3.7 pounds skim milk
1 pound oil meal is equivalent to 9.3 pounds skim milk
1 pound soy bean meal is equivalent to 10.7 pounds skim milk.

The following table, based on these figures, shows the value of ski milk as compared to these other feeds as supplements to grain feeds.

COMPARATIVE VALUE OF SKIM MILK AND OTHER SUPPLEMENTS TO THE CEREAL GRAINS FOR PIG FEEDING.

When 100 *lbs. tankage* costs.	100 lbs. *skim milk* is worth.	When 100 *lbs. middlings* cost.	100 lbs. *skim milk* is worth.	When 100 *lbs. oil* meal costs.	100 lbs. *skim milk* is worth.	When 100 *soy bean* meal costs.	100 lbs. *skim milk* is worth.
$2 00	$0 22	$1 00	$0 27	$1 50	$0 16	$2 00	$0 19
2 25	25	1 25	33	1 75	19	2 25	21
2 50	28	1 50	40	2 00	21	2 50	23
2 75	31	1 75	47	2 25	24	2 75	26
3 00	33	2 00	54	2 50	27	3 00	28
3 25	36	2 25	61	2 75	29	3 25	30
3 50	39	2 50	67	3 00	32	3 50	32
3 75	42	2 75	74	2 75	34	3 75	35
4 00	44	3 00	81	3 50	37	4 00	37
4 25	47					4 25	39
4 50	50					4 50	41
4 75	53					4 75	43
5 00	56					5 00	46

Reference to this table, which shows the relative values of the different nitrogenous supplements commonly used with farm grown grains, should enable the feeder to decide which of these feeds would be most profitable at prevailing prices at any time. Skim milk, tankage and middlings are very commonly used and are all very palatable to the pig in combination with grain feeds. Oil meal shows a very high value in comparison with the others but is less desirable as it is not so palatable and pigs do not eat it as readily.

BUTTERMILK.

Table I shows that buttermilk has practically the same composition as skim milk and feeding trials at several stations (Massachusetts, South Dakota, and North Carolina) where skim milk and buttermilk have been compared, showed very little difference in their feeding value. While buttermilk is produced in much smaller quantities than skim milk, still the 1917 production of buttermilk in Michigan is estimated at nearly 120,000 tons, so that the feeding value represented is no small item. Unlike skim milk, the bulk of the buttermilk is produced at creameries and must be shipped or hauled back to the farm if used for feeding purposes. This necessitates extra expense for shipping and hauling and as a result large quantities of buttermilk are often thrown away entirely for lack of suitable means of disposal.

WHEY.

Whey production in Michigan during 1917 is estimated at approximately 34,000 tons. Whey is not a very satisfactory feed for calves, but for pig feeding purposes has about 50% the value of skim milk, according to extensive experiments at Wisconsin and Ontario. The analysis in Table I shows that whey differs in composition from skim milk and buttermilk principally in protein, the latter having been removed in the form of casein in making the cheese. For this reason whey should be used in combination with other feeds which will supply the necessary protein. Whey should be fed up as promptly as possible as it

deteriorates rapidly, especially when held in storage tanks which are not often cleaned.

The one great drawback to the use of any of these by-products from the creamery or cheese factory is the danger of spreading disease. Where the milk from a tuberculous herd is taken to a creamery or cheese factory the by-products taken back to the farms may spread the infection through all the herds of pigs in the community. This danger may easily be averted by thorough pasteurization and all dairy by-products returned to the farm should first be put through this process.

READ THIS FIRST.

SPRAYING IS NECESSARY TO INSURE GOOD FRUIT.

PREPARE FOR THE WORK IN ADVANCE WITH EQUIPMENT AND MATERIAL.

TO BE SUCCESSFUL YOU MUST BE ON TIME, DO A THOROUGH JOB, AND USE THE RIGHT MATERIALS PROPERLY COMBINED.

THE DIRECTIONS GIVEN IN THIS BULLETIN ARE "GENERAL" AND UNDER AVERAGE SEASONAL MICHIGAN CONDITIONS THEY WILL BE SATISFACTORY. SHOULD YOU AT ANY TIME BE UNCERTAIN, INQUIRE OF YOUR COUNTY AGENT OR WRITE TO THE MICHIGAN AGRICULTURAL COLLEGE.

GENERAL TREATMENT FOR SPRAYING APPLE ORCHARDS.

Special Bulletin No. 93

BY H. J. EUSTACE AND R. H. PETTIT.

IN THE FALL, WINTER OR EARLY SPRING, make an inspection for scale-insects. Look on the twigs and branches of trees in different parts of the orchard. The kind most commonly found are: SAN JOSE, OYSTER-SHELL, SCURFY, and the EUROPEAN FRUIT-SCALE. If you cannot identify them, send twigs or a strip of bark to The Entomologist, Michigan Agricultural College Experiment Station, East Lansing, Michigan. Scale-insects are serious pests, (especially the San Jose), and must be destroyed.

JUST BEFORE THE BUDS OPEN, if scale is found, spray with strong lime-sulphur or Scalecide or some other efficient scale destroyer. (See directions for making and using on page 531.) *Be thorough in this. Cover every part of the tree.*

AS SOON AS THE BLOSSOM BUDS SEPARATE IN THE CLUSTERS, WHILE THEY ARE "IN THE PINK," a spraying must be made to prevent SCAB, the CANKER-WORM, the BUD-MOTH and possibly a few other insects, as PLANT-LICE and RED-BUG. Read the instructions for these on the following page.

For this spray may be used Bordeaux-mixture or lime-sulphur for the Scab and to each 50 gallons of either add for chewing insects two or three pounds of arsenate of lead paste or from 1 to 1½ pounds of arsenate of lead powder or ¾ pound of arsenate of calcium powder. If plant-lice or red-bug are present when this spraying is to be made, add to the Bordeaux or dilute lime-sulphur and poison, ½ pint of "Black Leaf 40" or some other 40% nicotine-sulphate solution.

IMMEDIATELY AFTER THE BLOSSOMS FALL, and before the calyx closes make another spraying. Use the same materials as in the previous application, *but if plant-lice or red-bug are not found, the "Black Leaf 40" or other 40% nicotine solution will not have to be added.* This is an *important spray especially for the Codling-moth (worm).*

ABOUT TWO WEEKS AFTER THE ABOVE APPLICTION, make another. Use the Bordeaux-mixture or lime-sulphur, plus poison, as before.

ABOUT THE FIRST WEEK IN AUGUST, there will be a second generation of codling-moths to do sérious damage to fall and winter varieties. A spraying is necessary to destroy them and frequently a late summer development of the Scab fungus is serious. For this treatment use Bordeaux-mixture or lime-sulphur, plus the full amount of poison.

THE LESSER APPLE-WORM works more superficially than the codling-moth. Sometimes it merely mines under the skin. It resembles the codling-moth in many ways, but is smaller. When present it requires a spray of poison to be applied when the standard winter varieties are from 1½ to 2 inches in diameter. This spraying should be thoroughly done. *It takes the place of the second application after the petals fall.* The other regular sprays will also help to keep the Lesser Apple-worm *in check.*

PLANT LICE of several kinds infest the apple tree, but their effect on the fruit depends largely on weather conditions. The red-bug is also now well distributed over the State. The eggs of both these insects are

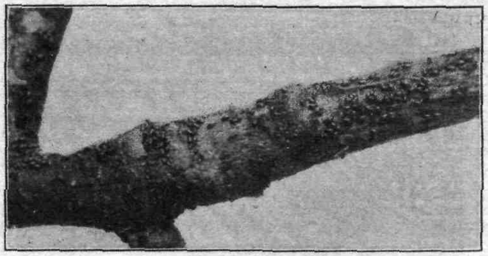


Fig. 1.—Eggs of plant-lice on apple-twigs.

hatched out by the time the buds turn pink, and at that time the plant-lice are easily killed and the adults of the red-bug are unable to fly. If either the rosy-louse or the red-bug is strongly suspected of being present,

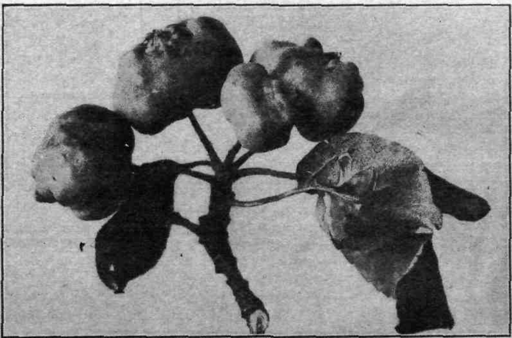


Fig. 2.—Apples stunted and deformed by rosy-lice and green-lice.

apply a spray of nicotine-sulphate, using a pint of Black Leaf 40, or of some other 40% nicotine-sulphate, to 100 gallons of water, adding 2 or 3 pounds of soap to the mixture; or else add a pint of the 40% nicotine-sulphate to 100 gallons of Bordeaux or dilute lime-sulphur. Stir the

nicotine in just before applying, and be sure to omit the soap in this case. An early spring with warm, dry weather following is unfavorable to the lice, and a cold, wet, late spring is favorable to the lice. In seasons such as the latter, spraying is almost imperative. As both these insects feed by sucking the sap from the foliage and from the fruit, it is necessary to use a contact spray and the safest contact spray, besides being the only one that can be mixed with lime-sulphur or Bordeaux, is nicotine-sulphate.

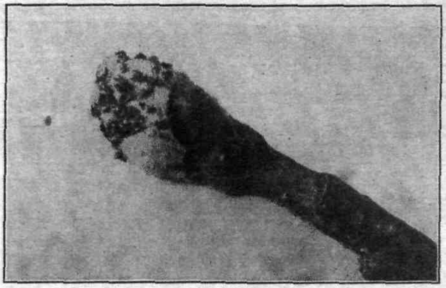


Fig. 3.—Bud-lice on apple just as leaf-buds are breaking out in spring. This condition closes the time for dormant sprays.

FIRE BLIGHT. Fire Blight is sometimes a serious disease in apple trees. A constant watch should be kept for its appearance from the time the trees blossom until the end of the growing season. For a description and method of control see "TREATMENT FOR PEARS."

GENERAL TREATMENT FOR SPRAYING PEACH ORCHARDS.

Peach orchards of Michigan may require spraying while they are dormant for two troubles. SCALE-INSECTS may be found. Inspect the trees as is directed for apples. PEACH LEAF-CURL is a very common and in some seasons a serious disease. (The leaves curl and drop off with the young fruits.) It is especially serious on the Elberta, and in foggy regions near lakes. If scale is found and a spraying can be applied before the buds swell and the bud scales open, this one treatment will destroy the scale and effectually prevent the leaf-curl. Use strong lime-sulphur. If scale is not found, make a spraying for the leaf-curl when the tree is dormant in late fall, winter, or early spring. Use 1½ gallons of lime-sulphur of 33° Baumé with enough water to make 50 gallons. The disease cannot be controlled if the spraying is not done before the buds begin to swell.

The summer spraying of peach orchards may be a very profitable practice in preventing decayed, scabby and wormy fruit. The rot usually appears just before harvesting and may develop in the package after shipping. The scab (the black specks on the skin) seriously detracts from the appearance, and the work of the curculio produces blemishes. Spraying also increases the bright and desirable color, so much that some progressive growers find it "pays to spray for color."

The above troubles are commonly found in most Michigan peach orchards, and may be best controlled by the following sprayings.

JUST BEFORE THE BLOSSOMS DROP AND MOST OF THE "SHUCKS" HAVE FALLEN: *In orchards where the curculio is found to be serious, make a* spraying of poison, using 2 pounds of arsenate of lead paste or 1 pound

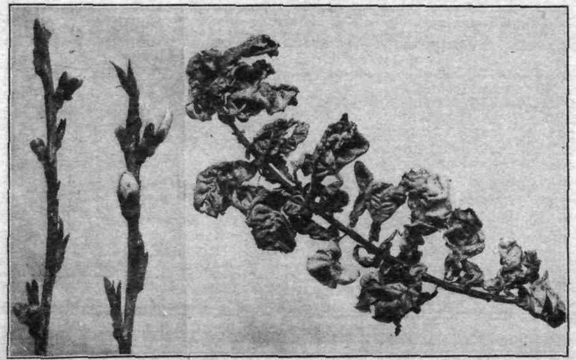


Fig. 4.—Too late to spray for peach leaf curl. Bad case of peach leaf curl.

of the powder with 2 or 3 pounds of slaked lime (to make sure there will not be any foliage burning), in 50 gallons of water. This poison is better for peach spraying than any other. If the curculio is not present or not serious, this spraying need not be made.

ABOUT TWO WEEKS AFTER THE "SHUCKS" HAVE FALLEN, make a spraying with self-boiled lime-sulphur, and to every 50 gallons add 2 pounds of arsenate of lead paste or 1 pound of arsenate of lead powder. The self-boiled lime-sulphur settles rapidly, so keep well agitated and do not add the arsenate of lead until just before spraying. Use fine nozzles and give the tree a uniform coating of mist-like spray. This spraying is to prevent the fruit rot, scab and the curculio.

ABOUT ONE MONTH BEFORE THE FRUIT RIPENS spray once more as directed above.

PEACH TREE BORER. Dig out by hand early in the spring or late in the fall at points where the gumming shows. Sterilize the knife with 2 to

5% lysol after finishing with each tree, in order to prevent the spreading of crown-gall which is often present. Careful experiments made, both here and elsewhere, have failed to produce any other treatment that actually pays for the cost of application. In order to facilitate the removal of the larvæ or "worms," many growers practice MOUNDING OR DITCHING. It seems to be of advantage to change the level of the soil around the base of the tree, either raising the level by making a mound of which the tree is the center, or lowering the level by digging away the soil in June and allowing the soil to be worked back by cultivation. Undoubtedly it is easier to pull away the mound to expose the injured crown than to dig out the soil. The mound is later replaced after the wounds have dried. On the other hand, most growers that do not mound, do leave the soil out of the pit dug around the base of the tree in "worming" until it fills during the summer, thus allowing time for the sun to dry the wounds and toughen the surface. There is also present in Michigan the Lesser Peach-borer, which works more in the body and limbs, and the upper part of the tree.

PEACH YELLOWS. A very infectious disease the cause of which is unknown.—The first symptoms in a young tree previous to bearing, are indicated by the leaves of one or two limbs turning from a rich dark green to a "yellowish-green or reddish rusty-green" color; this is accompanied by a rolling of the leaves from their edges. These leaves ripen and fall earlier than normal leaves. The fruit-beds are larger and more mature in appearance and in the spring will invariably bloom earlier than healthy buds. In some instances, the symptoms are not confined to one or two branches, but many of the leaves in the center of the tree turn yellowish or light-green, roll slightly at their edges and droop considerably. These later symptoms are often present in case of "Little Peach."

Upon bearing trees, there may be any one or all of the following symptoms: The fruit may ripen prematurely—one to three weeks—upon one or two branches or over the entire tree. The fruit may have numerous red spots on the surface, the spots sometimes extending in red streaks partially or wholly through the flesh to the pit. Often the flesh, about the pit, is full of radiating streaks of red. The surface of the fruit may be smooth or considerably roughened and the flesh more or less stringy and very insipid. The leaves may be yellowish pale or reddish rusty-green in color, usually rolling and drooping. In advanced stages, numerous finely branched shoots bearing many slender, sickly leaves, appear on the trunk or main limbs and sometimes near the ends of the branches. Finally the tree dies.

Winter injury to the bark of the trunk or main limbs, mechanical injury by mice, rabbits, peach-borers, cultivators, etc., or a serious lack of moisture or nitrogen in the soil may discolor the foliage and cause premature ripening of fruit and should not be mistaken for "Yellows."

The only method of control is by the destruction of an infected tree—fruit, root and branch—just as soon as discovered. It is especially important that diseased trees should not be allowed to blossom, as it is believed that the disease is spread by insects at that time.

LITTLE PEACH. In "Little Peach," characteristic symptoms are: The leaves of a part or the whole of the tree have a bunched appearance, and are shorter, and broader than normal leaves. They are usually yellowish-

green in color with veins appearing dilated and darker than the intervening tissue. The fruit is usually under size and ripens from a week to two weeks late. The flesh is more or less stringy, watery and very insipid, while the pit is usually very small. One or all symptoms may be present and unless they can be positively attributed to some other cause, the tree should be condemned, pulled out and burned.

GENERAL TREATMENT FOR PEAR ORCHARDS.

In the Fall, Winter or Early Spring, *inspect for scale insects the* same as for apple orchards, and if found, spray as is directed for apple orchards. (See page 518.)

A spraying for scale will also control the Pear Blister-mite, (a mite that causes thickened red and brown spots on the leaves and fruit). This insect has been a serious pest in parts of Michigan for the past few years.

Just as the Pink of the Blossoms is Showing, a spraying should be made to prevent scab, Codling Moth, Bud Moth, etc. For this spraying Bordeaux-mixture or the diluted lime-sulphur may be used to which add 2 or 3 pounds of arsenate of lead paste or one-half as much of the powder or ¾ pound of arsenate of calcium for each 50 gallons. If lime-sulphur is used, the following dilutions should be followed. They are not quite as strong as for apple orchard spraying.

If the concentrated lime-sulphur Baume test is 33, 32 or 31 use 1 gallon and water to make 50 gallons.

If the test is 30, 29 or 28, use 5 quarts and water to make 50 gallons.

If the test is 27, 26 or 25 use 6 quarts and water to make 50 gallons.

Immediately After the Blossoms Fall, and before the calyx closes, make another spraying using same materials as in the previous spraying.

The Pear Psylla is a serious and important insect regarding which pear growers must be fully informed. It passes the winter in rubbish, such as prunings left in or near the orchard, on the trunks of the trees, in the cracks and crannies of the rough bark, and on the twigs among the buds. It may be controlled by the following thorough treatment:

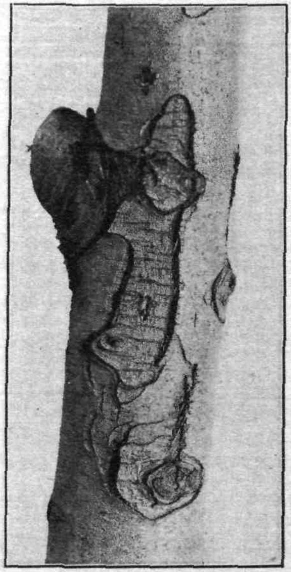
1. Late in the fall, November or December, scrape the loose bark from the trunks and large limbs and gather and burn or bury. Do not leave on the ground.

2. On a bright and fairly warm late fall day the insects will come out of their hiding places and can then be killed with a contact spray. Use "Black Leaf 40" or some 40% nicotine-sulphate solution at the rate of 1 pint in 100 gallons of water and to make it spread easily and quickly and so go farther, add 3 pounds of dissolved soap. Any cheap soap will do. Spray both sides of each tree, the insects are lively and will dodge the spray. The best possible job can be done by spraying both sides of each tree at the same time, or at least by completing the job before any one part of the sprayed trunk or limbs becomes dry.

Pear Blight commonly called Fire Blight. This is one of the most serious diseases of pears, and often does a great deal of injury on apples, especially on Russian varieties, young trees of many varieties, and on quince. Its presence is made very apparent by the discoloration of the foliage, the leaves turning dark brown, withering, but still holding to the

branches. The disease frequently appears about blossoming time, effec ing the tips of the quick growing shoots and working down to the larg branches. It is usually more serious in rapidly growing trees and fo this reason nitrogenous fertilizers, cultivation and any practice th would tend to stimulate growth should be withheld in infected orchard

Spraying is not a preventative. Inspect all trees in early spring fo cankers or sunken, irregular areas on the bark of the trunk and larg



Before Treatment. After Treatment.

Fig. 5.—Blight Canker on Pear Tree.

branches, around the edges of which the disease is carried from one seaso to another. Cut out all of these cankers, disinfecting every cut with five per cent lysol solution. Make frequent and thorough inspection through the orchard during the growing season, cutting out all disease twigs and branches some little distance below the point where the woo appears to be dead. Disinfect the pruning tool with lysol solution afte each cut.

When Slugs Appear spray with arsenical, if not too near picking tim of fruit to be dangerous. In case of early pears, fresh hydrated lime ma be heavily dusted on.

GENERAL TREATMENT FOR PLUM ORCHARDS.

Plum trees may be attacked by the San Jose or European fruit scale. If found, make a spraying before growth starts with strong lime-sulphur or other efficient scale destroyer, the same as directed for apple orchards.

JUST BEFORE THE BUDS OPEN *spray* with dilute lime-sulphur or the Bordeaux-mixture and to every 50 gallons add 2½ or 3 pounds of arsenate of lead paste or one-half as much powder. This is to prevent the leaf spot, brown rot, black knot, and curculio.

IMMEDIATELY AFTER THE BLOSSOMS FALL it is very essential to make a spraying to prevent leaf diseases, brown rot, and curculio. Use dilute lime-sulphur or Bordeaux-mixture. (On Japanese varieties use only the self-boiled lime-sulphur). For each 50 gallons of whatever is used, add 2 pounds of arsenate of lead paste or 1 pound of the powder.

This is an important spraying. Be on time and be thorough.

TEN DAYS OR TWO WEEKS LATER it may pay to repeat the previous spraying, especially if the weather is wet or the curculio serious. With varieties that are susceptible to the brown-rot, it may pay to make sprayings every ten days or two weeks until there is danger of staining the fruit; stopping at least a month before picking time. If desirable to make later applications use a spray of weak copper sulphate. One pound of copper sulphate to 150 or 200 gallons of water. Poison need not be used.

BLACK KNOT. Early in the spring a careful inspection should be made of every tree, and *all* "black-knots" cut out and destroyed. Cut back several inches below the knot. Disinfecting cuts as for pear-blight is not necessary. Wild cherry trees harbor the disease and if diseased ones are near plum or cherry orchards, the wild trees should be destroyed, if possible.

GENERAL TREATMENT FOR CHERRY ORCHARDS.

Inspect sweet cherries for scale. If found spray as for apple orchards. Sour cherries are not often attacked by the San Jose scale, and there is therefore seldom need of spraying them with the strong lime sulphur.

JUST BEFORE THE BLOSSOMS OPEN, spray with dilute lime-sulphur to prevent leaf-spot and brown rot.

JUST AFTER THE BLOSSOMS FALL, spray with dilute lime sulphur or Bordeaux-mixture and to every 50 gallons add 2 pounds of arsenate of lead paste or one-half as much of the powder. This spraying is to prevent the leaf-spot, brown rot and the curculio and slugs.

TEN DAYS OR TWO WEEKS AFTER the above spraying, it may be necessary to make another application of the same mixture. The necessity for this spraying will depend somewhat on the susceptibility of the variety to the brown rot and the leaf spot and on the weather conditions, moist weather being favorable to the development of these troubles.

LARGE BLACK LICE may appear on the leaves at any time. A spray of nicotine-sulphate will destroy them if applied before the leaves curl.

SLUGS sometimes appear after the fruit is harvested. A spray of arsenate of lead (2 or 3 pounds of the paste or half as much of the powder in 50 gallons of water) will destroy them.

CHERRY FRUIT-FLY. *Two sorts of small white maggots are often found* in ripening cherries. These footless maggots are the larvae of cherry fruit-flies. The only way to successfully combat these fruit-flies is to

Sour cherry tree not sprayed for leaf spot. Fig. 6. Sour cherry tree sprayed for leaf spot.

lightly spray or sprinkle the trees with arsenate of lead when the flies are preparing to lay their eggs in the immature fruit. Use about a pint to a tree of a mixture containing 4 pounds of arsenate of lead paste or 2 pounds of powder to 100 gallons of water.

GENERAL TREATMENT FOR GRAPE VINEYARDS.

Grape vines are not often subject to attack by scale insects, so there is seldom need for spraying with *strong* lime-sulphur before growth starts.

Do not use *dilute* lime-sulphur at any time for spraying grapes. It stunts or checks the growth of the berries. Use Bordeaux-mixture instead.

BLACK ROT is a serious disease. Growers cannot afford to risk the loss it may cause by neglecting to spray.

DOWNEY MILDEW, commonly called "Red Grape," is sometimes a destructive disease.

These diseases and others will be prevented very largely by spraying as follows:

WHEN THE SHOOTS ARE ABOUT 8 TO 10 INCHES LONG, spray with Bordeaux mixture for black-rot and downy-mildew.

JUST BEFORE BLOOMING, spray again with Bordeaux-mixture for black-rot and downy mildew, and to every 50 gallons of Bordeaux, add 2 or 3 pounds of arsenate of lead paste, or half as much of the powder, or ¾ pound of arsenate of calcium, to poison the grape-berry moth and the rose-chafer. If this latter is serious, use stronger poison, even up to 5 pounds of arsenate of lead paste or half as much powder, to 50 gallons. A pint of the cheapest molasses added may help.

JUST AS THE BLOSSOMS ARE FALLING, make another spraying like the above.

ABOUT 10 DAYS OR TWO WEEKS LATER, it may be necessary to make another spraying like the two previous, but this will depend upon the weather conditions and the amount of rot and mildew prevalent. If later sprayings are thought to be necessary, some material should be used that will not stain the fruit, such as weak copper sulphate solution. (See page 536.)

There are several grape insects that are found only in occasional vineyards, and then not every year. The grower should keep a sharp watch of his vines for them, and if found, take prompt measures to destroy them. (If not familiar with their appearance send specimens to The Entomologist, East Lansing, Michigan.)

Those most likely to be found are the following:

FLEA-BEETLES *may appear at any time, but are most likely to come as* the buds open in early spring. Spray with Bordeaux mixture and a strong poison, 3 or 4 pounds of arsenate of lead paste, or half as much of the powder, or ¾ pound of arsenate of calcium, to every 50 gallons of the Bordeaux, if early in spring. Later use less poison.

In vineyards where the grape-berry moth is serious, spray with Bordeaux and an arsenical poison during the middle of July, before the twentieth.

FOR LEAF-HOPPERS, *sometimes incorrectly called "Thrip,"* spray with nicotine-sulphate, using 1 pint to 100 gallons of water with 2 or 3 pounds of soap, or with kerosene-emulsion while the insects are young, and before they can fly. Try to hit each insect, for only those hit by the spray are killed. Later in the fall, clean up all rubbish and burn after cold weather sets in. *The leaf-hopper passes the winter in rubbish.*

FOR CLIMBING CUT-WORMS, use bands of cotton batting, or wool from the fleece, or bands of sticky mixture. On tender growth the latter can be put on strips of paper; also sprinkle poisoned bran near the bases of the vines. (See page 539.)

GENERAL TREATMENT FOR CURRANTS AND GOOSEBERRIES.

San Jose and European fruit-scale are often found on currants, although *seldom on gooseberries. Inspect carefully for them. If found,* spray before growth starts with *strong* lime-sulphur.

JUST AS THE LEAVES ARE EXPANDING, spray with dilute lime-sulphur or Bordeaux and 2 pounds of arsenate of lead paste or half as much of the powder, or ¾ pound of arsenate of calcium, to every 50 gallons.

REPEAT *this spraying when the fruit is about one-fourth grown.*

If worms trouble after this use pyrethrum or hellebore.

LEAF BUGS OR APHIDS may appear, either one or both together. When they do, spray with nicotine-sulphate while the bugs are red and wingless and before the leaves have become curled. Spray upward from beneath.

GOOSEBERRY MILDEW *is a fungous disease that is especially troublesome* on such English varieties as Industry, Columbus and Chautauqua. Spray with dilute lime-sulphur. Begin when the buds start and repeat every *10 days to two weeks until* near picking time.

WHEN PRUNING, if a cane shows discolored pith when cut, it may indicate the cane-borer. Cut back to sound pith. Burn trimmings immediately.

WILTED FOLIAGE at any time may indicate the cane-borer. Cut out and burn.

GENERAL TREATMENT FOR RASPBERRIES, BLACKBERRIES AND DEWBERRIES.

CUT OUT THE FRUIT BEARING canes after the last picking has been made. This will lessen insect and disease troubles that may be harbored on the old canes and allow more room for the growth of the new canes.

ORANGE RUST may appear in May or June. It is easily identified by the bright orange color on the under sides of the leaves. There is no method of preventing this trouble. As soon as it is found, the bush should be dug out and burned. If allowed to remain the disease will spread and destroy many plants. Secure disease free plants in starting new plantations.

ANTHRACNOSE. A common and troublesome disease especially of black raspberries and blackberries, identified by the grayish spots generally near the bases of the canes. Recent spraying experiments prove the necessity of three applications of lime-sulphur solution to control it, applied—first, in early spring just before growth begins, using 2½ gallons, testing 33° Beaume, to 50 of water; second, when the new canes are six to eight inches long, using 1¼ gallons to 50; third, just before blossoming, at the same rate as previous spray. The removal of all grass, weeds and trash in the plant rows, keeping them clean and well cultivated, will help to prevent this disease.

"WORMS" OR "SLUGS" may appear at any time. Spray with an arsenical if early in the season, but it near picking time, use hellebore or pyrethrum. Cut out and burn gouty galls, tree-cricket eggs and borers in stems.

GENERAL TREATMENT FOR STRAWBERRIES.

Examine the young plants before setting them. Pick off all discolored or diseased leaves. If root-lice are suspected, dip the roots in strong nicotine solution.

After the growth starts, spray with Bordeaux and an arsenical poison to prevent the leaf-spot, and destroy the leaf-roller insect that may be present.

For fruiting plantations, spray with Bordeaux before blossoming, and repeat ten days to two weeks later. After fruiting, if the bed is to be fruited again, mow and burn over quickly (as on a day when there is a wind, to avoid burning the crowns of the plants). If LEAF-ROLLERS have been present in the immediate past, spray with poison after the growth has started again, but before the leaves curl.

FOR STRAWBERRY ROOT-LICE, see Michigan Bulletin No. 244, page 88.

GENERAL TREATMENT FOR POTATOES.

SCAB AND BLACK SCURF. Where there is little or no evidence of Black Scurf (*Rhizoctonia*), the dormant stage of which may be seen on the skin

of the tubers in the form of small brownish, or when wet, nearly black spots, the tubers should be soaked for not less than ½ hour and 1½ will do no harm in a solution of formaldehyde, forty per cent, used at the rate of one pound or one pint to thirty gallons of water. This will destroy the disease known as Scab. Formaldehyde can be secured of any druggist.

If there is evidence of the Black Scurf, soak the uncut tubers in a solution of corrosive sublimate (bichloride of mercury), using four ounces in four gallons of hot water, and when this is dissolved, add enough water *to make 30 gallons. Soak the seed for not less than ½ hour and 1½* hours will do no harm, but no longer. Use only wooden vessels for this material.

Corrosive sublimate is a deadly poison and should be kept away from children and livestock. Do not use treated potatoes for eating purposes.

When and How to Treat. The potatoes may be treated with either material several weeks, if desired, before planting if care is taken not to re-infect the tubers by placing them in used sacks or crates which have *not been disinfected. Some growers prefer to treat just before planting.* The potatoes should be treated before the seed is cut.

When only a few bushels of potatoes are to be treated they may be placed in gunny sacks and submerged in a barrel from which the head has been removed.

When large quantities are to be treated, a tank should be provided for the purpose. The tank should be wide enough to allow two rows of potato crates to be placed in it side by side and deep enough so the potatoes, crates and all, can be submerged. It may be made any length desired. As soon as the potatoes are treated, it is a good plan to submerge them in clear water or to pour water over them to prevent further action of the material with which they are treated. If they are to be kept some time before they are planted, they should be spread out and dried.

For the Blight and "Bugs." Begin spraying with Bordeaux-mixture and poison when the "bugs" first appear, or when the plants are about 8 inches high, and repeat about every two weeks as long as the plants are growing. Spray often in warm, muggy weather; fewer sprayings are necessary in dry weather.

Use Bordeaux-mixture (6 pounds copper sulphate and 4 or 5 pounds of lime to 50 gallons of water, and put in the poison, about ½ pound of Paris-green or 2 or 3 pounds of arsenate of lead paste, or half as much of the powder, or ¾ pound of the powdered arsenate of calcium, or 1 quart of the stock solution of Kedzie-mixture. This amount of Kedzie-mixture is equivalent to ½ pound of Paris-green. Some growers prefer to use even more than this.

Dilute lime-sulphur is not as good as the Bordeaux-mixture for potatoes.

Potato Aphis. During wet summers and especially during those that follow cold, wet springs, the potato-louse is apt to appear. This potato-louse is not such a difficult insect to kill if one can only reach it with a spray. The difficulty comes from the fact that it hides under the foliage of the potato, and that the spray must be directed upward from beneath in order to hit any large proportion of the lice. Several devices have been made for bringing about this result. The spray most efficient is the

ordinary 40% nicotine sulphate, used at the rate of 1 pint to 100 gallons of water with 3 or 4 pounds of laundry soap added.

THE GRAY FIELD-SLUG (*Limax agrestis*) of Europe has finally become established in Michigan. It is a snail, less than ¾ of an inches long, without a shell, and it flourishes in moist places, feeding mostly at night on lettuce, celery, potatoes (the tubers) and other vegetables. Poisoned bran is the best we can do for it at this time. Scatter the bait in vicinity of plants to be protected. (The Giant Slug is also present in Michigan, but has not become widespread as yet.)

GENERAL TREATMENT FOR TOMATOES.

LEAF BLIGHT. This disease can be prevented by the proper use of Bordeaux. The standard 4-4-50 formula is the strength most commonly used. The first application should be made while the plants are in the seedbed or coldframe. The second spraying should be made soon after the plants are set in the field. This should be followed by additional sprayings every ten days or two weeks until the fruit begins to ripen. During wet seasons more and later sprayings are necessary than when the weather is comparatively dry.

FLEA-BEETLES. Small, black flea-beetles sometimes appear and eat pits in the foliage of the tomato plant. The easiest way to control them is to spray with Bordeaux-mixture and arsenate of lead in the ordinary way. Such sprays, of course, must not be continued after the fruit begins to get very large.

TOMATO WORMS. The large green "worms" that devour the leaves of the tomato plants can be controlled when the worms are small by a spray of arsenate of lead applied in the ordinary way.

GENERAL TREATMENT FOR MUSKMELONS AND CUCUMBERS.

Several insects interfere with the welfare of cucumber and melon vines. THE CUCUMBER-BEETLE (striped) feeds on the leaves, and the young tunnel as grubs in the roots. Plant more seeds than are needed to produce vines and thin out the injured plants and dust with hydrated lime and flour of sulphur (one of sulphur to five or six of lime), through coarse cloth. Some prefer arsenate of lead powder mixed with nine parts of hydrated lime. About the bases of the vines on the ground throw some tobacco dust to prevent beetles from laying eggs on stems. Paris-green is not reliable on these tender vines.

THE CUCUMBER-LOUSE usually starts in a few hills and then spreads over the field, cold, wet weather being favorable to the louse. Some prefer to bury the first few vines attacked to retard spreading. A good spray is Persian insect powder, ½ ounce to a gallon of water; also nicotine-sulphate, ½ pint to 50 gallons of water, if 40% sulphate is used, spraying upward from beneath. The difficulty lies in getting the spray on to the lice. Each louse must be fairly hit to be killed.

THE LARGE BLACK SQUASH-BUG, or stink-bug, not only feeds on vines, but probably also carries the wilt. It may be trapped on cold nights under pieces of board and dropped into a can of water, having a little kerosene on top.

PREPARATION OF SPRAY MIXTURES.

Commercial Concentrated Lime-Sulphur is now very extensively used by Michigan fruit-growers. Many may be saved by making the "home-made" if much spraying is to be done, but in times of labor shortage the advantages of the "Commercial" apparently outweigh in the minds of the majority of fruit-growers the money saving.

There are several brands of the "Commercial" concentrated lime-sulphur wash now on the market. Under "Agricultural Laws of Michigan" a label on each container must state plainly "the correct names and percentage amounts of each and every ingredient of the insecticide or fungicide having insecticidal or fungicidal properties and the total percentage of inert ingredients present."

The "strength" or "Baume Test" in concentrated lime sulphur may be known from the "*Total Percent Sulphur*" given on the label of commercial manufacture.

When *Total Percent Sulphur* is 26, Baume Test is 33.
When *Total Percent Sulphur* is 25, Baume Test is 32.
When *Total Percent Sulphur* is 24, Baume Test is 31.
When *Total Percent Sulphur* is 23, Baume Test is 30.
When *Total Percent Sulphur* is 22, Baume Test is 29.
When *Total Percent Sulphur* is 21, Baume Test is 28.

When the Baume Test is known, make the dilutions as follows:

Where the directions are for *strong lime sulphur* for San Jose and other scale insects and the plants are dormant or just before the buds open.

For summer spraying of apples, cherries and European varieties of plums.

When Baume test is	Amount of concentrated lime sulphur below should be diluted to 50 gallons.	When Baume test to	Amount of lime sulphur below should be diluted to 50 gallons.
33	5½ gallons	33-32 or 31	1¼ gallons
32	5¾ gallons	30-29 or 28	1½ gallons
31	6 gallons	27-26 or 25	1¾ gallons
30	6¼ gallons	24-23 or 22	2 gallons
29	6½ gallons		
28	6¾ gallons	For Summer Spraying of Pears.	
27	7 gallons		
		33-32-31	1 gallon
		30-29-28	1¼ gallons
		27-26-25	1½ gallons
		24-23-22	1¾ gallons

HOME MADE LIME-SULPHUR.

There are two ways of making lime-sulphur at home.

For dormant spraying to destroy scale-insects the old formula may be followed. It is not much used now, but has given excellent results. The formula is:

Lump Lime—20 pounds.
Sulphur (flour)—15 pounds.
Water (hot) to make 50 gallons.

The lime is slaked with a small amount of water (hot if lime is sluggish, and the sulphur is added, 15 or 20 gallons of water are then added, and the mixture boiled: (It should take three-quarters of an hour, or an hour of good boiling with frequent stirring). When done the liquid should be amber colored and fairly clear. Strain, dilute with water (hot is preferable) to make (up to) 50 gallons, and apply warm, through a coarse nozzle.

If small quantities are required, use an iron kettle to boil it in. If larger quantities are to be used, live steam is preferable for boiling purposes, either in a tank or in barrels.

Applied just before the buds swell, it coats the branches in such a way as partially to hinder from settling down, such pests as the San Jose, oyster-shell, scurfy scale, some aphids and other insects.

Lime-sulphur may be made at home in the *concentrated form* and used immediately after diluting with water to the strength desired for dormant or summer spraying or stored until wanted and then diluted.

There are several ways of combining the lime and sulphur but always there are two parts, by weight, of sulphur to one of lime. These three formulas are used:

Stone Lime	75 lbs. or	60 lbs. or	40 lbs.
Sulphur	150 lbs. or	120 lbs. or	80 lbs.
Water	50 gal. or	50 gal. or	50 gal.

The lime is slaked to a thin paste and the sulphur is added. Boil for an hour and stir frequently. Water should be added so that there will be 50 gallons at the end of the boiling. Where live steam is used this probably will not be necessary.

Special "spraying lime" should be secured if possible. It may be found on many markets. Lime that contains more than 5 per cent of magnesium oxide does not make a satisfactory wash.

After cooking it may be stored in barrels or tanks which should be airtight, as exposure to the air causes the sulphur compounds to lose their value for spraying purposes. If tanks are used cover the lime-sulphur with a film of oil.

TESTING AND DILUTING CONCENTRATED LIME-SULPHUR.

Every "batch" of the home made concentrated lime-sulphur wash will have to be tested when cooled and settled to determine its strength and it will be well to test the "commercial" brands. This testing is done with A Baume hydrometer. It is a simple instrument used to determine the

weight and density of liquids. It is made of glass, is about a foot long, and has a graduated scale on the side.

It is absolutely necessary that the hydrometer be kept *perfectly clean*. If the solution is allowed to dry on it an accurate test cannot be made.

It can be purchased from dealers in druggists' supplies or from Bausch and Lomb Optical Company, Rochester, N. Y., or Whitall Tatum Company, Philadelphia, Pa., or Taylor Instrument Company, Rochester, N. Y.

(See page 543 for the rates of dilutions.)

DILUTE LIME-SULPHUR SOLUTION.

For spraying on the foliage of apples, pears, European plums and cherries, but not on peaches or Japanese plums, grapes or potatoes.

This solution can be prepared for use in several ways.

First, the "Commercial" concentrated lime-sulphur solution can be diluted to the proper strength.

Second, "The home made" concentrated lime-sulphur can be diluted to the proper strength.

Third, The solution can be made at any time and in any quantity as follows: Boil in a few gallons of water for one hour, *twice* as many pound of sulphur as of lime, strain and dilute with water so there will be 8 pounds of sulphur to every 100 gallons.

Example: To make 100 gallons of spray solution, boil 8 pounds of sulphur and 4 pounds of lime as directed.

SELF-BOILED LIME-SULPHUR MIXTURE.

This is a mixture of lime, sulphur and water and not like any of the other lime-sulphur sprays. It does not (when properly made) injure tender foliage and is very valuable for spraying peaches and Japanese plums. The formula is:

Lump lime	8 pounds.
Sulphur	8 pounds.
Water	50 gallons.

The mixture can be prepared better by using 32 pounds of lime, 32 pounds of sulphur, and 8 or 10 gallons of water, and then diluting to 200 gallons.

Place the lime in a barrel and add enough water to almost cover it; as soon as the slaking begins add the sulphur, which should be run through a sieve to break up the lumps.

Stir constantly and add enough water to make a thick paste and then, gradually, a thin paste. As soon as the slaking of the lime has vigorously boiled the sulphur for about five minutes, cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted up to the full formula, and used.

Care must be taken not to allow the boiling to proceed too far, if the mixture remains hot for fifteen or twenty minutes after the slaking is completed, too much sulphur will go into solution and injury to the foliage may result.

The time of adding the cold water to stop the boiling depends upon the lime. With a sluggish lime all the heat in it may be needed, while

with limes that become intensely hot, care must be taken not to allow the boiling to proceed too far.

DRY OR POWDERED SUBSTITUTES FOR THE LIQUID LIME-SULPHUR.

Substitutes for the liquid lime-sulphur in the dry or powdered form are now offered on the market. They *may* have an advantage over the liquid in economy of shipping and may be a little easier to handle. They will dissolve in water and are then used exactly as is the liquid lime sulphur, poison is added as desired.

The value of these substitutes should depend upon the amount of sulphur they contain, and sufficient quantities must be used to make a spraying mixture strong enough to be efficient.

Their relative value compared with concentrated liquid lime-sulphur is given in the table below:

COMPARISONS OF DRY SUBSTITUTES WITH LIQUID LIME SULPHUR.

Material.	Amount per 50 gallons of spray	
	For Dormant Spray	For Summer Spraying
Concentrated Liquid Lime Sulphur at 33°	5½ gal.	1.¼ gal.
Dry Lime Sulphur	26 lbs.	6.1 lbs.
Sodium Sulphur or Soluble Sulphur	26 lbs.	6.1 lbs.

Knowing the *amount of material required for 50 gallons* and the cost per pound, the expense as compared with the liquid lime-sulphur, either the commercial concentrated, or the home-made may be determined.

DUSTING COMPARED WITH SPRAYING ORCHARDS.

The practice of dusting orchard trees with sulphur and poison in powder form, instead of spraying them with lime-sulphur or Bordeaux-mixture has received the attention and consideration of fruit growers for the past few years. The advantage of dusting as compared with spraying is chiefly in the time saved and the ease of doing the work.

For several years the Horticultural Section of the Experiment Station has conducted tests to compare the results of dusting and of spraying. These tests have been made in orchards in different sections and include the standard varieties of apples.

The results in 1917 as stated in Special Bulletin No. 87 are quoted as follows:

"Dusting method gave very satisfactory results in 1917. The results equaled those secured in the sprayed plots. The season was like that of 1916 in that the infection periods were all early in the summer. The control of scab on the fruit was very satisfactory in most plots. The condition of foliage in the dusted plot at Muir was much better than on the sprayed trees because of the spray injury on the latter. At Belding there was little difference in the condition of the foliage of the two plots.

At Morrice the foliage of the dusted trees was free from injury but showed some scab, while on the sprayed trees there was no scab but some spray injury.

"It is not possible to tell just why the results with dusting were so much more satisfactory in 1917 than in previous years. This success may have been due to one or all of the following factors: More efficient application of dust, finer materials or more timely applications with relation to infection periods.

"Better results were obtained at Morrice and Muir where much of the dusting was done when the trees were wet with either rain or dew than at Belding where the trees were always dry when material was applied. Several growers, however, have secured satisfactory results by dusting when the foliage was dry.

"It is very doubtful if the extra application of dust made in July had any beneficial effect as weather conditions were not favorable for scab infection before the August application."

Tests were continued in 1918 but conclusive results were not secured. Both the dusted and the sprayed trees produced good crops of fine clean fruit, and the check trees (those left unsprayed for comparison) had only a small percentage of fruits injured by scab, although they were considerably damaged by the codling moth.

Commercial fruit growers who have tried dusting instead of spraying have had various experiences. No definite nor conclusive general results can be drawn from these experiences. Many of them are satisfied with dusting while others will continue to use the sprays.

We are compelled to state that the use of dusting material as a substitute for liquid mixtures is still in the experimental stage.

SUGGESTIONS.*

For the benefit of fruit growers who may care to use the dusting method at this time, a few suggestions may prove helpful.

A duster of sufficient capacity and power should be used. Efficient work cannot be done with an undersized machine.

Special dusting sulphur should always be used. The ordinary grades of sulphur are not satisfactory.

Home-mixing of materials should not be tried unless a special mixing machine is used.

Applications should be made from two opposite directions and preferably when there is not any wind.

Unlike spraying, dusting can be safely done when the foliage is wet.

More applications of dust than are usually made of the liquid sprays will probably be desirable. However, the number will depend largely upon weather conditions. The applications of dust should, of course, be made before scab infection periods. Cool and rainy weather is favorable to scab development.

BORDEAUX MIXTURE.

Bordeaux mixture is made of copper sulphate, lime and water.

These three substances are combined in various proportions, depending upon the kind of plant to be treated. For apples, pears, cherries and plums (except Japanese varieties) the preparation is usually four pounds of copper sulphate, with about the same amount of lime, to fifty gallons of water. Poison is added as needed. The copper sulphate will readily dissolve in two gallons of hot water, to which should be added enough water to make 25 gallons, or one-half barrel. Do not use an iron or tin vessel to dissolve this in, as the copper sulphate will destroy it, and besides the iron will spoil the Bordeaux. A wooden pail is good. Slake the lime into a thin paste and add water to make 25 gallons. Pour, or let these run together into a third barrel, and the Bordeaux is made. When it is emptied into the spray barrel or tank, it should be strained through a brass wire strainer to catch any of the coarse particles.

Whenever it is necessary to use a quantity of the mixture, it is desirable to have the lime and copper sulphate in "stock solutions." A quantity of lime is slaked to a paste and held so by being covered with water. The copper sulphate, say 50 pounds, is placed in a clean gunny sack and suspended in a barrel (one with wooden hoops is much to be preferred) containing 25 gallons of water. This will dissolve in about a day. One gallon of this "stock solution"** is equal to two pounds of copper sulphate.

A good quick way to combine these three substances is as follows: Put the amount of the "stock solution" of copper sulphate required in a barrel, and add enough water to make 25 gallons, or one-half barrel. Put about 7 pounds of the lime paste in a barrel and add 25 gallons of water, making a thin whitewash. Pour, or let these two run together into a third barrel, or directly into the spray barrel or tank, being sure to strain. When partly run in, test with ferro-cyanide of potash to make

*From Special Bulletin No. 87. Dusting and Spraying Experiments with Apples.

**Always stir this "stock solution" before dipping any out, in order that what is used may be full strength.

sure enough lime has been used. If Paris-green, arsenate of lead, or any other poison is to be used, make it into a thin paste with a little water and add it to the Bordeaux-mixture, which is now ready to be used.

COPPER SULPHATE SOLUTION.

Copper sulphate solution is copper-sulphate dissolved in water. It is used by some growers to spray peach trees to prevent the leaf curl where a spraying for scale insect is not required. Two pounds of copper-sulphate to 50 gallons of water is strong enough for this purpose.

PREPARED BORDEAUX. There are many brands of prepared Bordeaux-mixtures upon the market, sold under various proprietary names. Some of them also contain arsenical poisons. In our tests of these materials, we have not found them as efficient or as economical in controlling fungous diseases as a properly home-made Bordeaux.

POISONS USED IN SPRAYING.

For Insects That Chew.

ARSENATE OF LEAD.

This poison is used very extensively. It can be obtained either as a paste or as a dry powder. The powder is about twice as strong as the paste, and *only half as much of it is required in preparing spray mixtures.* Consequently it usually costs about twice as much as the paste per pound. Arsenate of lead is ready for use at any time and does not readily injure foliage. Furthermore, this poison can be safely used in the lime-sulphur sprays. Injury to tender foliage like the peach has occasionally occurred after spraying with arsenate of lead and water when the foliage was moist from dew or rain. When it is necessary to spray such tender foliage as that of peaches or Japanese plums, it is well to add from three to five pounds of freshly slaked or of hydrated lime to 50 gallons of poison spray.

A simple easy way to work the thick pasty arsenate of lead into a thin, smooth paste is to put the amount required in a keg, add water and churn with a dasher, such as is used in an old-fashioned stone churn. The mixture is made much more quickly than when a paddle is used for stirring.

ARSENATE OF CALCIUM.

A new arsenical spraying material is coming into the market at the present time—arsenate of calcium. It has been tested to some extent during the past season, notably on potatoes and apples, and seems to resemble arsenate of lead in its nature and in its action on chewing insects. It costs a little less than arsenate of lead and is designed to take the place of the latter poison. This substitution would be desirable because of the necessity for using lead in other ways. Arsenate of calcium is sold as a very finely ground powder, and when used at the rate of 15% with hydrated lime or with other diluent it seems to be entirely successful in dusting operations. It can also be combined with

some other dusts. Some little time will be required to establish it as beyond doubt the equivalent of arsenate of lead for use in watery mixtures. At present we are not recommending its use on stone fruits. It is hoped that eventually arsenate of calcium will take a place of equal importance with arsenate of lead in many sorts of spraying operations, and that it will prove as reliable when mixed with fungicides and contact sprays as the better known poison. The strength ordinarily recommended is ¾ pound of the powder to 50 gallons of water, lime-sulphur or Bordeaux. When used alone in water, it is advisable to add two or three pounds of freshly slaked lime to each barrel of the spray.

PARIS-GREEN AND LIME.

Never mix Paris-green with lime-sulphur in any form. Paris-green can, however, be used with Bordeaux-mixture with safety.

For spraying from a barrel, the writer has found the following method very useful: Place from ¼ to ½ pound of good lump lime, or unslaked lime, in each of 3 or 4 tin pails which will hold about 3 quarts or less. Old cans or crocks will answer just as well. Add enough hot water to slake it into a thin cream or paste. Now add to each lot ¼ pound of Paris-green, previously weighed out, and placed in paper bags; stir while the lime is hot and allow to stand for some time. Now measure out about 44 gallons of water in your spraying barrel, and make a mark that will show how high it comes in the barrel; add the contents of one tin pail (viz., ¼ pound of Paris-green and ½ pound of quick-lime slaked) into the 44 gallons of water in the barrel. Stir well and spray. The pails or crocks can be used one at a time and re-filled occasionally so that the stock is always on hand ready for use.

ARSENATE OF CALCIUM—KEDZIE-MIXTURE.

This mixture, originated by the late Dr. R. C. Kedzie, of this station, is cheap, but it has the disadvantage of lacking a warming color. It is a good substitute for Paris-green, but must be made with care, and stored in well-labeled jugs. It is made of white arsenic (not arsenate of lead) and carbonate of soda.

Dr. Kedzie in giving directions for its preparation says: "Dissolve the arsenic by boiling with carbonate of soda, and thus insure complete solution; which solution can be kept ready to make a spraying solution whenever needed. To make the material for eight hundred (800) gallons of spraying mixture, boil two pounds of white arsenic with eight (8) pounds of sal-soda (crystals of carbonate of soda—'washing soda'—found in every grocery and drug shop) in two gallons of water. Boil these materials in any iron pot not used for other purposes. Boil for fifteen minutes or until the arsenic dissolves, leaving only a small muddy, sediment. Put this solution into a two-gallon jug and label, 'Poison,' stock material for spraying mixture."

"The spraying mixture can be prepared whenever required, and in the quantity needed at the time by slaking two pounds of (stone or lump) lime,* adding this to forty gallons of water; pour into this a pint of the

*Three pounds of fresh hydrated lime may be made to take the place of the two pounds of stone or lump lime.

stock arsenic solution. Mix by stirring thoroughly, and the spraying mixture is ready for use. The arsenic in this mixture is equivalent to four ounces of Paris-green."

"The pot, jug, etc., must never be used for any other purpose after using it for making this mixture."

If an additional pound or two of lime be added to the mixture it will help to make the application permanent and conspicuous without in any way interfering with its effect.

The final product obtained in the spraying tank is *arsenite* of calcium (not arsenate of calcium) which kills more quickly than arsenate of lead or arsenate of calcium. The formula given above was designed for spraying fruit trees. When this poison is used for potatoes, use twice as much of the stock solution, or 1 quart to 40 gallons of water. Some potato growers prefer to use it even stronger than this.

CONTACT INSECTICIDES.

For Insects That Suck.

NICOTINE.

The insecticide most generally used for sucking insects, at the present time, is nicotine. Nicotine is a clear, colorless, odorless material *when pure*, although the commercial preparations contain impurities which impart both odors and color to the spray. It is marketed in two forms: the volatile, plain nicotine and the non-volatile nicotine-sulphate. For use in greenhouses and forcing houses, the volatile, plain nicotine is preferable because it disappears from the plants treated rather rapidly, without leaving any deposit which would be dangerous or offensive. For out-door work, however, the sulphate is much to be preferred, since it is stable and does not evaporate and pass off into the air for a considerable length of time, at least. A favorite strength for marketing nicotine is 40%, although some of the plain nicotines are put out at 10% and some even stronger than 40%. All references to nicotine made in this bulletin refer to the use of 40% nicotine-sulphate, since the bulletin deals with outside spraying and is not intended to include remedies for crops grown under glass or for vegetables such as lettuce, where the sprayed part is to be eaten soon after the application. Nicotine-sulphate may be stirred into the dilute lime-sulphur or arsenate of lead or a combination of the two immediately before the spray is applied. It should not be stirred and allowed to stand before the application is made. In case nicotine is added to any other spraying compound, soap should never be added. In case, however, nicotine is used by itself alone and diluted with water, soap adds greatly to its efficiency by causing it to spread better and perhaps in other ways. The favorite strength used in orchards and small fruit spraying is 1 part to 800, in other words, 1 pint to 100 gallons of water with 3 or 4 pounds of soap, or 1 pint to 100 gallons of dilute lime-sulphur without soap. Some growers dilute the nicotine still further, using 1 part to 1,000 of water or other spraying material. Of course, if one uses 10% nicotine, one should use four times as much

of it as if 40% nicotine were employed, and any strengths of nicotine other than those mentioned should be diluted in proportion to their strengths.

KEROSENE EMULSION.

Place two gallons of ordinary kerosene in a warm place, either in a warm room or in the sun, and allow to become as warm as possible without danger from fire. Boil 1 pound of laundry soap or whale oil soap in a gallon of soft water until completely dissolved. Remove the soap solution from the fire, and while still boiling hot, add the kerosene and agitate vigorously for 10 minutes, or until the oil is emulsified, with a spraying pump by forcing the liquid back into the vessel from which it was pumped. When the liquid is perfectly emulsified it will appear creamy in color and will flow evenly down the side of the vessel when allowed to do so. Care should be taken to completely emulsify the oil and this is accomplished much more easily when the mixture is hot.

This strong emulsion may now be readily diluted with water and used, or it may be stored away for future use. When cold it becomes like sour milk in appearance and should be dissolved in three or four times its bulk of hot water before diluting with cold water. If the water is at all hard, "break" it by adding a little sal-soda before putting in the soap.

Small amounts of this emulsion may be made by using the ingredients in small quantities, but in the same relative proportion. It is used at the rate of 8 or 10 parts of water to 1 part of emulsion.

HELLEBORE.

White hellebore is the powdered root of a plant. It kills both by contact and as an internal poison. It may be applied either dry or in the form of a liquid. When used dry it should be mixed with three or four times its weight of flour or of plaster and then dusted on the insects. Applied wet, one pound should be mixed with twenty-five gallons of water and this liquid applied as a spray.

INSECT POWDER, BUHACH, PYRETHRUM.

This valuable remedy has one drawback—its cost. It is too expensive for use on a large scale. It kills insects through their breathing pores, but is harmless to man and beast. It will kill many of the insects of the garden if dusted on or applied as a spray at the rate of 1 ounce to 2 gallons of water.

Use the powder when it is undesirable to use poison, but never buy any unless it comes in tightly sealed packages. It loses its strength on short exposure to the air. An hour will suffice to weaken it. It must be applied from time to time, as it quickly loses its strength.

HYDRATED LIME.

Freshly hydrated lime is sometimes useful, because of its slight caustic properties. It is especially useful against such larvæ of saw-flies and beetles as are sticky, as well as those of the cherry slug and of the asparagus-beetle. The lime may be dusted on and used as a substitute

for a poison if the latter for some reason is undesirable. This is not to be confused with ground quick lime, which is used in making Bordeaux-mixture, the latter being very caustic and likely to burn the foliage. Nor should hydrated lime be confused with air slaked lime, since the latter is not caustic at all. Hydrated lime, when dusted on sticky larvae, clings to their bodies and attacks them through their skins.

POISONED BRAN (KANSAS BAIT).

Sift together 1 pound of Paris-green or ¾ pound of white arsenic (*not arsenate of lead*) and 20 pounds of bran; add half a gallon of molasses or syrup and a little water, and stir in three oranges or lemons, ground fine in a food-chopper, skins and all. This may be broad-casted over from 2 to 5 acres of land. It is very attractive to both cut-worms and to grasshoppers. Do not try to substitute any other poison for the Paris-green or white arsenic. Neither arsenate of lead nor arsenate of calcium will do the work unless very large quantities of the prison are used. Neither should one use this bait where poultry are likely to pick up much of it, although the bait should be distributed in a finely broken up condition rather than in lumps.

CRIDDLE MIXTURE.

Criddle-mixture is horse manure mixed with an arsenical, and slightly salted. It is to be distributed about the field in small masses, and is especially useful in combatting grasshoppers, as it takes advantage of their well-known love of salt. The proportions are about as follows:

Paris-green, 1 pound; salt, 2 pounds; fresh horse manure, 100 pounds or five 3-gallon pailfuls. The salt is dissolved in a pail of water, the poison stirred in, and the whole mixed with the horse manure in a half barrel.

LYSOL.

For sterilizing knives, saws, shears and other tools, nothing is better than lysol used at the rate of from 2 to 5%, diluted with water. Lysol has the advantage that it helps cleanse the tools and softens dirt that might otherwise cling to them. It is useful for cleansing and sterilizing tools used in pruning where diseases are present and for sterilizing the knife used used in cutting out peach-borers, in order to avoid distributing crown-gall through the orchard.

POISONED SYRUP FOR ONION MAGGOT.

Dissolve 5 grams or ¼ ounce of *sodium arsenite* in 1 gallon of hot water and add half a pint of New Orleans molasses. Distribute a small amount of this in small basins covered with wire screen of small enough mesh to keep out bees, using 15 or 20 of these basins to the acre, and put the pans in position just as the onions begin to nicely get through the ground keeping them replenished until the danger is past. It is said that the efficiency of this bait is increased if a slice of onion is added to the syrup in each pan.

Two tablespoonfuls of the stock solution of Kedzie-mixture will take the place of the 5 grams of arsenite of soda.

CAUTIONS.

Do not spray while plants are in bloom. It is prohibited by law, except when canker-worm is present, and may destroy bees and other *beneficial insects.*

Do not dissolve copper sulphate in an iron or tin vessel. It will ruin the vessel and spoil the spraying solution.

For all spraying solutions containing copper sulphate, the pump must be brass or porcelain lined.

Wash out pump and entire outfit each time after using.

Use *arsenate of lead on stone fruits in preference to other forms of* arsenical poisons. It is less liable to burn the foliage.

Do not spray fruits or plants with poison within a month of the time when they are to be picked.

Keep all "stock solutions" covered to prevent evaporation, and oxidation. If a "spray gun" is used try to do the work when the mixture will dry on the tree quickly.

Do not use lime-sulphur solution as a summer spray for grapes, potatoes or tomatoes.

Do not use Paris-green or Kedzie-mixture in combination with lime-sulphur sprays.

TABLE OF DILUTIONS FOR CONCENTRATED LIME-SULPHUR WASH.

To spray for San Jose and other scale insects when plants are dormant or just before buds open in Spring.		Summer spraying for Apples, Cherries, *and European Plums.*	
If Baume test is	Amount below should be diluted to 50 gallons.	If Baume test is	Amount below should be diluted to 50 gallons.
33	5½ gallons	33, 32 or 31	1¼ gallons
32	5¾ gallons	30, 29 or 28	1½ gallons
31	6 gallons	27, 26 or 25	1¾ gallons
30	6¼ gallons	24, 23 or 22	2 gallons
29	6½ gallons	21, 20 or 19	2¼ gallons
28	6¾ gallons		
27	7 gallons		
26	7½ gallons		
25	7¾ gallons	Summer Spraying of Pears.	
24	8 gallons		
23	8¼ gallons		
22	8¾ gallons		
21	9¼ gallons	33, 32 or 31	1 gallon
20	9½ gallons	30, 29 or 28	1¼ gallons
19	10 gallons	27, 26 or 25	1½ gallons
18	10¼ gallons	24, 23 or 22	1¾ gallons
17	10¾ gallons	21, 20 or 19	2 gallons

THE FINANCIAL HISTORY OF A 12-YEAR OLD PEACH ORCHARD

Special Bulletin No. 94

BY H. J. EUSTACE AND F. M. BARDEN.

INTRODUCTION.

The peach has always been an important commercial horticultural crop in Michigan. The earliest ventures in extensive fruit growing were with peach orchards in Western Michigan. No other fruit crop has a history of so many or so great financial successes or failures, and largely for these reasons fruit growers are always especially interested in the crop and everything pertaining to it. The financial record of twelve years of this 15-acre orchard will be of value and interest.

The financial account of any orchard enterprise is interesting to every owner of a similar property as it gives a basis of comparing their own costs and returns with others and may shed some light on orchard values, and the prospective fruit grower is always anxious to know the probable costs and returns.

PEACH PRODUCTION ON MICHIGAN FRUIT FARMS

Peaches are nearly always grown on Michigan fruit farms along with other fruit crops. With the production of several other crops a system of farm management can be better and more economically managed.

Also, the income from the farm is more likely to be uniform if more than one crop is depended upon. The peach is well-known to be a "fickle crop," and there are very few regions or orchard sites that can be depended upon to bring forth a regular crop.

DATA FOR SERIES OF YEARS DESIRABLE

The financial statement of one or a few years of an orchard property is not of much value and it may be used in a misleading way. The only fair way to judge of returns from an orchard, especially a peach orchard, is by averages of a reasonable number of years. The costs should be considered in the same way. The peach is the shortest lived orchard tree, it begins to bear at an early age and reaches its time of unprofitableness sooner than any other. For this reason the expenses of starting and development during the first years when crops are not produced should be charged against the later years of crop production.

CONDITION OF THE ORCHARD

The peach orchard considered here is owned by Messrs. J. K. Barden & Sôn. The records have all been taken by Mr. F. M. Barden. The orchard is of fifteen acres, located in Allegan County, Casco township, eight miles northeast of the city of South Haven. The early history of the orchard including a financial statement is given in Special Bulletin 63 of the Station in September, 1913, but the important points must be repeated here for a proper understanding for a later account.

The orchard is located on good soil, a gravelly, sandy loam in most parts but clay in a few. The sub-soil is clay or sand. There is a gradual slope to the south and west and lower surrounding land gives excellent air drainage.

Originally the land was covered with hardwood trees, beech and maple predominating. After clearing, general farm crops were raised. The present orchard is the third bearing peach orchard upon the same land. It was set in the spring of 1907 and includes 100 trees of New Prolific; 370 Engles; 200 Kalamazoo; 120 Gold Drop; 125 Elberta; 100 Banner; 100 Fitzgerald; 275 Smock, and 200 Salways. As is not uncommon, some were not true to name. Of the Smock 120 were Champion and nearly all the Banner were unknown. The nurserymen made a refund when the mistake was discovered. The trees were set 20 feet each way, which was a mistake; 24 feet or even more would have been better.

THE ANNUAL RECORDS OF THE ORCHARD

THE EXPENSES

This orchard is part of a farm upon which other crops are produced, as apples, pears, plums, and quinces, also some general farm crops and a small dairy.

All the labor whether performed personally by the owners or hired and horse labor whether done with teams owned or hired has been charged for at the "going rate" of the neighborhood. This varied with the kind of labor performed, the time of the year it was done, and with the different years. The pruning was considered "skilled labor." The cost of labor in the spring and summer months was less than in the fall and the labor bills for the first years were smaller than for the later years as was common with all labor. All expenses are charged to the orchard just as though actual cash was paid out or all the labor was hired. This is the correct way for purposes of accounting, but since the owners did considerable of the work themselves, they were getting pay for their labor in addition to the profit on their own property.

An account of every item of expense has been kept. These items may be divided into two groups. One of such items as are necessary for the maintenance of the orchard and must be assumed regardless of whether there is a crop or not and the size of the crop. They would include interest on the land, interest on the equipment, though most of it was also used for other crops, cost of the young trees and planting, pruning, dormant spray-

ing, cultivation, fertilizers and cover crop seeds. The other group of expenses may be called "crop expenses" as they were necessary only in the crop years and their size depends a good deal on the size of the crop. These included the cost of summer sprayings, thinning, harvesting, packing, hauling to the shipping station, and packages. A brief statement will be given for each year of the expenses, returns and profit or loss.

THE FIRST YEAR, 1907

EXPENSES		RETURNS	
Maintenance	$291 18	Corn Crop	$509 50
Crop	123 88		
Total for orchard	$415 06		
Total per acre	27 67		
Net profit for orchard			$94 44
Net profit per acre			6 29

Expenses include the cost of the young trees. This year a crop of corn was grown between the tree rows, providing besides cultivation a worthwhile revenue.

THE SECOND YEAR, 1908

EXPENSES		RETURNS	
Maintenance	$225 25	None.	
Crop	None		
Total for orchard	$225 25		
Total per acre	15 01		
Net loss for orchard			$225 25
Net loss per acre			15 01

A crop was not grown between the tree rows this year, though it might have been had there been pressing need for the land and the time taken from other work to put it in.

THE THIRD YEAR, 1909

EXPENSES		RETURNS	
Maintenance	$204 60	Refund from nurseryman for trees not true to name	$ 65 00
Crop	None		
Total for orchard	$204 60		
Total per acre	13 64		
Net loss for orchard			$139 60
Net loss per acre			9 30

THE FOURTH YEAR, 1910

EXPENSES		RETURNS
Maintenance	$238 28	None.
Crop	None	
Total for orchard....	$238 28	
Total per acre......	15 88	

Net loss for orchard....................	$238 28
Not less per acre.......................	15 88

A peach tree usually produces a fair crop its fourth year. This orchard gave promise of a good crop at blossoming time but the unseasonable cold weather blasted the prospects.

THE FIFTH YEAR, 1911

EXPENSES		RETURNS	
Maintenance	$276 53	2,039 bu. at $1.25.......	$2,548 75
Crop	495 90	25 bu. at $0.50..........	12 50
Total for orchard...	$772 43	Total for orchard...	$2,561 25
Total per acre.......	51 49	Total per acre......	170 75

Net profit for orchard.................	$1,788 82
Net profit per acre....................	119 26
Cost per bushel for this crop was.......	37
Net profit per bushel was..............	86

It should be noted that the returns from this first crop of fruit are much *more than enough to pay for all the previous expenses.*

THE SIXTH YEAR, 1912

EXPENSES		RETURNS	
Maintenance	$303 96	2,128 bushels	$2,920 99
Crop	528 88		
Total for orchard...	$832 84	Total for orchard...	$2,920 99
Total per acre......	55 52	Total per acre......	194 74

Net profit for orchard.................	$2,088 15
Net profit per acre....................	139 22
Cost per bushel for this crop was.......	39
Net profit per bushel was..............	98

During the past winter the farm thermometer registered 20° below zero, and some of the trees died which had appeared entirely healthy. This crop, larger than the previous year was borne on two-thirds of the orchard, as the lowest and highest part suffered the most injury from the cold.

THE SEVENTH YEAR, 1913

EXPENSES		RETURNS	
Maintenance	$322 89	1,800 bu. at $1.00........	$1,800 00
Crop	432 24		
Total for orchard...	$755 13	Total for orchard...	$1,800 00
Total per acre.......	50 34	Total per acre.......	120 00

Net profit for orchard.................	$1,044 87
Net profit per acre....................	69 66
Cost per bushel for this crop...........	42
Net profit per bushel..................	58

The comparatively small yield this year was due to a hard frost at blossoming time. The injury would have been more severe had not the orchard site been such as to provide good air drainage. The fruit was sold early in the season at a stated price. If sold at harvest time it would have brought fifty cents a bushel more.

THE EIGHTH YEAR, 1914

EXPENSES		RETURNS	
Maintenance	$358 89	3,107 bu. at $1.10.......	$3,417 70
Crop	933 88	753 bu. at .75.......	564 75
		66 bu. at .50.......	33 00
Total for orchard...	$1,292 77	Total for orchard...	$4,015 45
Total per acre......	86 18	Total per acre......	267 69

Net profit for orchard.................	$2,722 68
Net profit per acre....................	181 51
Cost per bushel for this crop...........	33
Net profit per bushel..................	69

The crop was again sold early in the season and for a better price than could have been secured at harvesting time.

The purchaser was the same as last season so his losses were in a measure offset by his gains of last year.

THE NINTH YEAR, 1915

EXPENSES		RETURNS	
Maintenance	$294 49	2,272 bu. at $0.48.......	$1,090 56
Crop	578 86		
Total for orchard...	$873 35	Total for orchard...	$1,090 56
Total per acre.......	58 22	Total per acre......	72 70

Net profit for orchard.................	$217 21
Net profit per acre....................	14 48
Cost per bushel for this crop............	38
Net profit per bushel..................	10

There was an unusually large peach crop in all sections this year hence the low price. It was impossible to make sales in advance so they were made at harvesting time.

THE TENTH YEAR, 1916

EXPENSES		RETURNS	
Maintenance	$254 57	3,103 bu. at $0.94.......	$2,832 22
Crop	809 94		
Total for orchard...	$1,064 51	Total for orchard...	$2,832 22
Total per acre......	70 96	*Total per acre*......	188 81

Net profit for orchard..................	$1,761 71
Net profit per acre....................	117 85
Cost per bushel for this crop...........	35
Net profit per bushel..................	59

This was a very satisfactory season. Nothing of unusual importance occurring.

THE ELEVENTH YEAR, 1917

EXPENSES		RETURNS	
Maintenance	$272 85	1,115 bu. at $1.50.......	$1,672 50
Crop	345 89		
Total for orchard...	$618 74	Total for orchard...	$1,672 50
Total per acre.......	41 25	Total per acre......	111 50

Net profit for orchard..................	$1,053 76
Net profit per acre....................	70 25
Cost per bushel for this crop...........	55
Net profit per bushel..................	95

The severe winter shortened this crop, although some varieties would have been light as not many fruit buds developed. A light crop throughout the country made a good price.

THE TWELFTH YEAR, 1918

EXPENSES		RETURNS	
Maintenance	$360 44	*614 bu. at $2.50*	$1,535 00
Crop	177 97	8 bu. at 3.00	24 00
		4 bu. at 2.00	8 00
		21 2-5 bu. at $1.75	37 45
		9 crates $2.50	22 50
Total for orchard	$538 41	Total for orchard	$1,626 95
Total per acre	35 89	Total per acre	108 46

Net profit for orchard	$1,088 54
Net profit per acre	72 57
Cost per bushel for this crop	82
Net profit per bushel	1 72

A very severe winter caused the small yield. Many trees were killed in neighboring orchards that were not well located. The old wood of nearly all of the trees was discolored and at picking time it was discovered the limbs were very brittle. Hardy varieties as the Kalamazoo and Gold Drop bore very well while the other varieties were light.

The crop was nearly all sold to a canning factory without sorting or grading.

A summary of all the accounts is given in Table I for ease of comparison.

TABLE I.—ANNUAL TOTAL EXPENSES AND RECEIPTS AND NET PROFIT OF 15-ACRE PEACH ORCHARD.

Year.	Age.	For entire orchard.			Per acre.		
		Total expenses.	Total receipts.	Net loss or profit.	Total expenses.	Total receipts.	Net loss or profit.
1907	1 yr.	$415 06	$509 50	$94 44	$27 67	$33 96	$6 29
1908	2 yrs.	225 25	None	L 225 25	15 01	None	L 15 01
1909	3 yrs.	204 60	65 00	L 139 60	13 64	4 33	L 9 31
1910	4 yrs.	238 28	None	L 238 28	15 88	None	L 15 88
1911	5 yrs.	772 43	2,561 25	1,788 82	51 49	170 75	119 26
1912	6 yrs.	832 84	2,920 99	2,088 15	55 52	194 74	139 22
1913	7 yrs.	755 13	1,800 00	1,044 87	50 34	120 00	69 66
1914	8 yrs.	1,292 77	4,015 45	2,722 68	86 18	267 69	181 51
1915	9 yrs.	873 35	1,090 56	217 21	58 22	72 70	14 48
1916	10 yrs.	1,064 51	2,832 22	1,767 71	70 96	188 81	117 85
1917	11 yrs.	618 74	1,672 50	1,053 76	41 25	111 50	70 25
1918	12 yrs.	538 41	1,626 95	1,088 54	35 89	108 46	72 57
Totals		$7,831 37	$19,094 42	*$11,263 05	$522 05	$1,272 94	$750 89

*The expenses are deducted for the three years (1908, 1909 and 1910) when there was not a crop. A diagram of the costs and returns is shown in Figure 1.

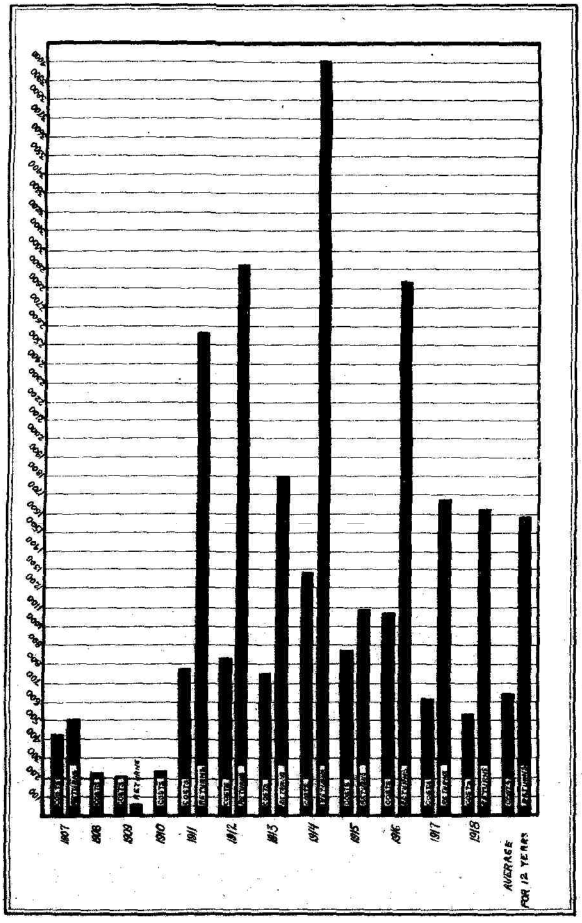


Fig. 1. Diagram of costs and returns for twelve years of fifteen acre peach orchard and average for the twelve years.

From this summary a balance sheet or a statement that tells the all important facts may be computed.

TABLE II—BALANCE SHEET FOR 15-ACRE, 12-YEAR OLD PEACH ORCHARD

EXPENSES		RETURNS	
Total cost for orchard	$7,831 37	Total returns for orchard	$19,094 42
Average cost per year	652 61	Average returns per year	1,591 20
Average cost per acre per year	43 50	Average returns per acre per year	106 08

Net profit for the orchard	$11,263 05
Net profit per year	938 58
Net profit per acre per year	62 57
Net profit per bushel (16,972)	66

An overhead charge should be made to provide for the orchard's share in the farm buildings, though none for the orchard especially have been erected, nor existing ones changed. Therefore, such an item can only be estimated and might be assumed at 2½ cents per bushel which would amount to $424.30.

Another expense would include the cost of clearing the land when the trees become unprofitable or killed by a freeze.

REMARKS

PRESENT CONDITION OF THE ORCHARD

The orchard is still in excellent condition. The crop of 1918 would indicate this following a winter of the lowest temperatures in many years. If the trees had been set 24 feet apart instead of 20 feet, it would have been better as they would have then developed more fruiting surface. However, there should be five or six more crops from this orchard before it becomes unprofitable from age. The first peach orchard on this site produced 12 crops and the second orchard was four years old when it was so badly damaged by the freeze of October, 1906, that it was pulled out but had produced one crop.

VARIATIONS IN THE YIELDS AND PRICES

One of the most prominent things in the account is the wide variations in the size of the crop and the prices received. The care of the orchard was the same every year; one season as near like another as possible. The crop did not increase regularly with the increased size or age of the trees. The weather for the year is all that will account for the differences, and shows its tremendous influence on peach production in this region, which is not unlike all parts of the state when peaches are grown commercially.

Peach crops of uniform size cannot be depended upon nor should they be expected. Averages must be the rule of measure.

Variation is not confined to yields but shows probably to a greater degree in the prices realized the different years. These differences are largely accounted for on the size of the general crop, and to some extent on the time of marketing this particular crop and the competition they happen to meet with at that time. This may be with peaches from nearby or far distant sections or from other products that can take the place of peaches. Uniform prices cannot be depended upon nor should they be hoped for, unless a contract is made for a term of years with a canning factory. However, this is not commonly done. The hope of a large crop and high prices is too alluring.

The good grower does not become discouraged with poor years or when he has a large crop to move at low prices or a small crop at only fair prices. He possesses a love for and faith in the business and a vision big enough to keep him ever hopeful and looking forward. The man who does not have these qualities had better leave peach growing alone.

NECESSARY CASH EXPENDITURES AND HARVESTING EXPENSES

From the complete accounts it is possible to select the items for which actual cash was paid. These would be nursery trees, spraying materials, fertilizers, and cover crop seeds. Labor is not included, though part of it was hired, but used for other crops produced on the farm. These items give a fair basis for comparison with similar orchards as peach orchards on most Michigan farms have been developed just as this one has, being a part of a general fruit farm, and the owner usually cannot tell how much it has cost further than to know the actual cash outlay.

TABLE III.—ACTUAL CASH SPENT FOR SUPPLIES AND MATERIALS FOR 15-ACRE PEACH ORCHARD.

Year.	For entire orchard.	Per acre.	Year.	For entire orchard.	Per acre.
1907	$122 55	$8 17	1913	$104 08	$6 93
1908	8 50	56	1914	138 71	9 24
1909	14 50	96	1915	49 98	3 33
1910	15 37	1 02	1916	51 72	3 44
1911	38 13	2 54	1917	59 31	3 95
1912	28 84	1 92	1918	48 92	3 26

The expenses in connection with harvesting the crop may well be considered by themselves. They are not incurred unless there is a crop of fruit and they depend upon the size of the crop. Furthermore they are not difficult to meet as buyers and marketing associations will usually make advances payments of sufficient size to more than pay for all harvesting expenses.

The amounts necessary to handle these crops will be of interest. They include the expenses of picking, sorting, packing, hauling, and packages.

TABLE IV.—EXPENSES IN CONNECTION WITH MARKETING CROP OF PEACHES FROM 15-ACRE ORCHARD.

Year.	Size of crop.	Expenses for orchard.	Per acre.	Year.	Size of crop.	Epxenses for orchard.	Per acre.
1911..........	2,064	$467 85	$31 19	1915..........	2,272	$535 52	$35 70
1912..........	2,128	511 93	34 12	1916..........	3,013	751 34	50 09
1913..........	1,800	405 87	27 05	1917..........	1,115	328 28	21 88
1914..........	3,926	866 26	57 75	1918..........	640	146 37	*9 75

*Packages were not purchased this year. The crop was sold to canning factory and packages furnished.

COST SHEET

A cost sheet for the life of the orchard is given in Table V. The relative costs and expenses of the many orchard and harvesting operations may be compared.

Year.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	Total.
Trees and planting	$139 43	$1 50	$4 25	$1 42	$5 75	$2 20	$3 40						$157 95
Corn crop	124 38												124 38
Dormant spraying, material and labor		5 25	8 60	14 92	24 43	27 44	28 60	$32 17	$25 44	$32 22	$45 60	$40 82	285 49
Summer spraying, material and labor					4 80		23 52	12 87	23 84	21 60	17 61	31 60	135 84
Pruning and removing brush		4 00	14 00	48 80	76 50	89 15	74 58	77 30	60 90	56 70	35 25	77 25	614 43
Hoeing and boring		6 00	6 00	4 65	3 90	5 10	5 40		11 85	4 35	13 00	10 00	70 25
Plowing and cultivation	43 50	67 50	69 75	43 27	49 95	53 02	42 60	38 70	46 05	48 15	53 00	110 37	665 86
Fertilizer, manure and application		39 00		9 80		21 75	50 56	92 00	34 00				247 11
Cover crops, seeds and planting	12 75	9 00	9 00	6 70	18 00	10 30	22 75	23 72	18 70	18 15	26 00	17 00	192 07
Thinning					23 25	16 95	2 85	54 75	19 50	37 00			164 30
Picking					82 35	85 05	77 60	184 00	125 00	174 57	98 75	80 57	907 69
Trucking to packing house					28 35	36 90	22 82	38 48	31 90	36 85	26 10	11 20	232 60
Packing					65 55	59 55	46 95	110 25	61 80	86 10	32 85	8 00	471 05
Hauling to shipping station					68 00	66 00	56 00	114 00	74 00	102 50	40 50	39 00	560 00
Packages					223 00	264 43	202 50	419 53	242 82	351 52	130 08	7 60	1,842 08
Equipment charge	5 00	3 00	3 00	5 00	5 00	5 00	5 00	5 00	5 00	5 00	10 00	15 00	71 00
Interest on land	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	1,080 00
Incidentals				13 72	3 00				2 55				19 27
Totals	$415 06	$225 25	$204 60	$238 28	$772 43	$832 84	$755 13	$1,292 77	$873 35	$1,064 51	$618 74	$538 41	$7,831 37

CONCLUSIONS

The orchard is an average one of the better class for the southwestern part of the state. The soil is good, the location such as should always be *selected for peaches. The care at all times has been intelligent and thorough.* It did not come into bearing unusually early and has lived through average and severe winters, the yields have been light and heavy, prices low and so high as to be spoken of as "record breaking." If it were destroyed now, it would have paid well.

MUSKMELON CULTURE IN MICHIGAN

Special Bulletin 95.

BY C. W. WAID.

Adaptability

The muskmelon is grown commercially in certain sections in the southern and central portions of Michigan. It is a favorite garden crop in all parts of the state where it can be matured. It is a heat loving plant, and does best where the summers are long and warm.

By starting the plants in a greenhouse or hotbed and transferring them to the open ground as soon as the weather will permit, muskmelons may be successfully grown where the summers are too short for the fruit to reach maturity when the seeds are planted in the open ground. The fruit will be of better quality when the rainfall is light than when it is excessive during the period of later growth and maturity of the melons, although a uniform supply of soil moisture is essential for best results.

The muskmelon may be grown on a variety of soils. As a commercial crop it is usually raised on loamy soils. A warm sandy loam because of the ease of working and earliness of maturity of the melons, is especially well suited to this crop. Practically any soil which can be used for gardening may be put in condition to produce melons. The location should, however, be free from danger of late spring and early summer frosts. The essential soil requirements are thorough drainage, an abundant supply of readily available plant food, and a mechanical condition which is like that of a virgin soil. It is fully as necessary that the soil be mellow and well supplied with organic matter, as it is that a good supply of plant food be available.

Rotation

If a rotation of crops is possible it will be advantageous to plan a system in which melons follow clover. Such a system helps add fertility, improves the mechanical condition of the soil and lessens the danger from melon diseases.

Even if a crop rotation is not practicable, as is usually the case on truck areas, the growing of clover or other legumes as a cover crop will help to keep the soil in good condition for other crops as well as for melons. A rotation of crops on a truck farm should be followed which will avoid the necessity of growing melons after melons. On small garden areas the hills of melons should be changed from one place to another each season.

Varieties

Careful consideration must be given to the selection of varieties whether grown for home use or for market. If the crop is grown commercially the market requirements must be known. For a local market in the southern part of the state the large fruiting sorts such as Osage (Miller's Cream) and Tip Top will usually be satisfactory. They are of superior quality

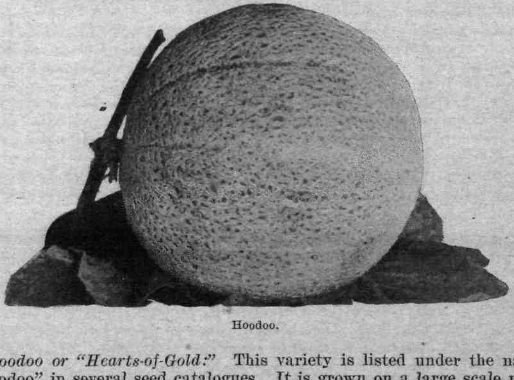
but are not as suitable for long distance shipments as are some of the smaller varieties. In selecting varieties for the home garden, quality comes first. The early maturing varieties must be selected for the cooler parts of the state.

Emerald Gem: A high quality extra early variety. Fruits medium size, nearly round, heavily ribbed. Flesh very thick and salmon in color. Small seed cavity, and thin rind. Too soft to ship well, but because of its earliness and good quality is well suited to the home garden.

Extra Early Hackensack: A light green flesh melon of good quality. Adapted to the home garden and suitable to ship. Its chief merit is early maturity.

Paul Rose, or Petoskey: A cross between Osage and Netted Gem. Of larger size than Rocky Ford and with deep orange flesh. Well adapted to shipping in baskets or crates.

Rocky Ford: The variety that has made Colorado famous as a melon growing state. Flesh green and when grown from pure seed and under good cultural conditions is of fine flavor. It is very uniform in size and especially well suited to the shipping trade.



Hoodoo.

Hoodoo or "Hearts-of-Gold:" This variety is listed under the name "Hoodoo" in several seed catalogues. It is grown on a large scale near Benton Harbor, Michigan, by Mr. R. Morrell, the originator, under the name of "Hearts-of-Gold." It was an accidental cross found in a field of Osage and supposed to be a cross between Osage and Netted Gem.

The vines are vigorous and productive. Fruit very uniform in shape and nearly round. The netting is very dense and fine, extending over practically the entire surface. The rind is thin but firm. Flesh very thick, salmon in color, of fine texture and superior flavor. An excellent shipping melon.

Osage or Miller's Cream: A popular green skin, salmon flesh variety of excellent quality. A favorite with the consumers when they learn to know the variety and its superior merit. Somewhat inclined to crack, especially when the soil moisture is variable. Well suited to the home market and home garden.

Osage.

Tip Top: A large sized salmon flesh melon of excellent quality. Requires a long season for its best development.

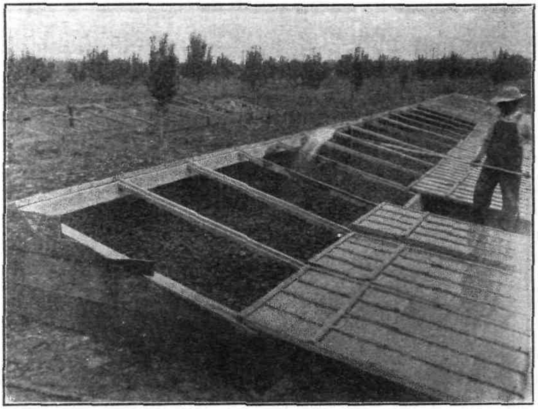
Seed Selection

Varieties of melons may be improved through proper seed selection. When saving seed, it is not enough to select the best melons without considering the vines upon which they grow. For profitable melon growing there must be quantity as well as quality. To get the most desirable seeds they should be saved from melons taken from vines which produced a large number of fruits of uniformly good quality and most nearly the ideal type. The character of the adjacent hills should also be taken into consideration, because of the likelihood of crosses having taken place. The ability of the plant to resist disease is also important. Disease resistant strains may be developed through proper and careful seed selection.

Starting the Plants

In the Greenhouse: It would not be economy to build a greenhouse in which to start melon plants, but growers who have greenhouses which are used for other crops usually make use of the houses for that purpose.

In the Hotbed: If a greenhouse is not available a hotbed is usually used in which to start the melon plants.*



Watering the plants in the hot bed.

In the Coldframe: A coldframe is similar to a hotbed, but it is not built as permanent and manure is not used in it to supply heat. When covered with glazed sash it may be used in which to start melon plants. It may also be used as a place in which to harden off the plants which have been started in a greenhouse.

Planting the Seed and Care of the Plants

The most common practice when plants are started under glass is to plant the seeds in soil placed in old strawberry baskets, paper or clay pots, or dirt bands. Some growers use inverted sods cut into squares in which to plant seeds. The soil used in the pots or dirt bands must be prepared with much care. One method in common use consists of composting sod and manure. The preparation of the compost heap is described in

* Full instructions for the construction of a hotbed and coldframe can be found in Extension Circular No. 20.

detail in Extension Circular No. 20. Another method is to mix well decomposed stable manure and garden loam soil. More manure should be used when it is mixed with soil than is necessary when it is composted with sod. In either case, thorough mixing should be done and the soil should be carefully sifted before it is ready for use.

Four or five weeks before the plants can safely be set in the field the melon seeds should be planted. When strawberry baskets, pots, or dirt bands, are used, they should be placed close together in the greenhouse, hotbed, or coldframe, and filled level full with this specially prepared soil and then compacted by pressing it with a piece of wood. Unless the soil is very moist it should be watered before the seeds are planted. From two to four seeds are placed in each basket, pot, or dirt band, and covered with not more than one-half inch of fine loose soil.

The temperature in the greenhouse or hotbed should be held as near 70° as possible at night and on cloudy days and at least 10° higher on bright

One day's picking of Osage.

days. Apply water only on bright days and early in the day so that the foliage will dry before night. Do not allow the plants to become dry enough to wilt, nor should they be over-watered. Give ventilation whenever the weather permits.

The melon plants must be hardened off before they are taken to the field. This may be done in the greenhouse by keeping the ventilators open wide, and in the hotbed by removing the sash. If a coldframe is available, it is a good plan to remove the melon plants from the greenhouse to the frames a few days before they are to go to the field. The plants are easily injured by low temperature and cold wind.

Preparing the Seedbed

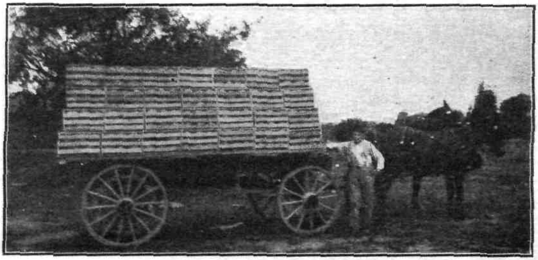
Some growers prefer fall plowing while others practice early spring plowing. In either case the soil should be worked as early as can be done in the spring. A deep, well pulverized seedbed is very essential for the

growth of the melon plants. It is not advisable to plant melon seeds or set melon plants until the soil has become warm and the danger of frost is past. Frequent harrowing from the first working until the seeds are planted or the plants set is necessary for best results. Such working will not only put the soil in good physical condition, but will destroy a good many weeds and make the work of later cultivating much easier.

Fertilizing

Manure: Well rotted stable manure is the best form of fertilizer for melons. Bulletin No. 155 Illinois Agricultural Experiment Station, "Fertilizer Experiments with Muskmelons," gives results secured by the Illinois Experiment Station and the manure applied broadcast and also in the hills gave the largest net return. When used in the hills it should be well composted or decayed.

Commercial Fertilizers: It is usually profitable to supplement the manure with commercial fertilizers. A 4-8-10 formula is recommended as one which may be used profitably on most soil types when the fertilizer



A wagonload of Melons ready to ship.

can be purchased at normal peace time prices. If clover is plowed under, the percentage of nitrogen may be reduced. From 500 to 1000 pounds per acre is the amount used by growers in various parts of the country. Lighter applications may be made when manure is used in liberal amount. When a heavy application of fertilizer is made, from one-half to three-quarters of it may be applied broadcast with a fertilizer distributor or a grain drill with a fertilizer attachment. The remainder of the fertilizer should be applied in the hills and thoroughly worked into the soil before the seeds are planted or the plants set. Nitrate of soda is sometimes applied in small amounts around the growing plants, but it must be used with care to prevent burning the foliage.

Planting the Seeds in the Field

Melon seeds may be planted in the field a few days before it is safe to set the plants. Care must be taken to drop the seeds into fine, moist soil.

If the soil is firmed with the hoe it is a good plan to draw a little more soil over the hills after the firming is done. It is well to plant a large number of seeds, a dozen or more, in each hill to overcome the injury or loss from cutworms and striped beetles. The seeds should be scattered in the hill, as there is less chance of the cutworms destroying all of the plants than when they are planted in a bunch. It is also a good plan to make two or three plantings a few days apart. This will insure a good stand and the extra cost of labor and seeds will not be large.

Setting the Plants

When the plants have been started in the greenhouse, hotbed, or cold-frame, take great care in transplanting not to disturb the roots or soil. It is easier to transfer plants started in sods or dirt bands without injury than when they are started in clay plots. When the plants are taken to the field, the dirt bands are lifted by means of a spade or flat shovel and

A promising field of Melons.

placed on a wagon bed with a level bottom. The band is not removed until the plants are in the hill, where they are to remain, and the soil has been drawn up closely about the outside of the band. The soil should be pressed gently about the plants, but not packed hard enough to disturb the roots.

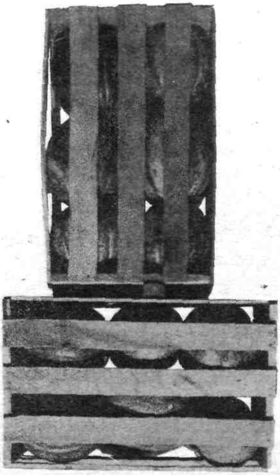
Spacing

Muskmelons are planted in hills or drills. On light soil where the vine growth is not heavy, four by four feet will be sufficient. On richer soils, five by five feet is better; and on some soils, six by six feet will not be too far apart. Some growers prefer five by seven, or four by six feet spacing. When the melons are drilled, the rows are seldom less than six feet apart, and the plants from one to two feet apart in the rows. One plant in a hill, as well as each plant by itself in the drill, is the more common practice. It is seldom advisable to leave more than two plants in each hill after

the vines have begun to form. Some growers thin to one plant in each pot or dirt band before transplanting to the field.

Cultivation

The day the plants are set the cultivator should be started. Cultivation should also begin as soon as possible when the seeds are planted in the field. Few crops respond as readily to frequent and thorough tillage as melons. It is injurious to the growth of the melon plants to allow the formation of even a slight crust about the plants unless it is broken very soon after forming. The cultivation should continue as long as is possible without danger of injury to the vines, and at frequent intervals. After the vines have begun to form, the cultivator should be kept at a safe distance from the plants, so that the vines will not be injured. All cultivations, after the first one or two, should be shallow. It is sometimes advisable to fasten a two by four or similar piece of wood to the back teeth of the cultivator to keep it from going too deep, and at the same time to leave the ground level.



Properly packed (below); poorly packed (above).

In some sections of the country melon growers are making a practice of "windrowing" the vines. This plan permits the running of the cultivator much later in the season than where the vines are allowed to spread over

the ground. It also makes the spraying and picking easier and there is less danger of damage to the vines by tramping when picking.

Harvesting

When the melons are to be sold on a local market they should be allowed to fully ripen on the vines. The stage of maturity can be determined by the color and netting of the skin and the condition of the stem where it connects with the melon. If the melon separates readily from the stem it is considered ripe. When the melons are to be shipped they should be picked somewhat sooner than is advisable for local trade. It requires experience and practice to tell just when each melon is ready to pick. To secure uniformity of ripeness and to avoid overripe melons the vines should be gone over carefully every day. A half bushel basket is a convenient gathering receptacle.

A good setting of Osage.

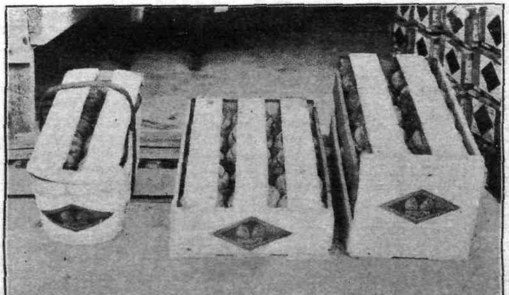
Preparing for Market

Melons should be graded as to size and quality. Hand grading is done except when the area grown is very large. In most cases three grades are

made. The size for the various grades will be governed largely by the kind of melon grown. Mr. R. Morrell grades his "Hearts-of-Gold" brand as follows:

"All sizes under four inches in diameter are culled out. All melons four inches in diameter are packed in standard crates which have 12 by 12 inch heads and are 24 inches long. These crates contain 45 melons when filled. All melons $4\frac{1}{2}$ inches in diameter are packed in flat crates with

A "Nest" of "Hearts-of-Gold."



Three kinds of Melon Packages.

4½ by 13½ inch heads and 24 inches long. The 5 inch grade is packed in flats with 5 by 15 inch heads and 24 inches long. The two sizes of flat crates each hold 15 melons.

"To grade for quality all imperfect and low quality melons are culled out before they enter the grader. All sizes are of as nearly uniform good quality as is possible to judge of them from outside appearance. Frequent cutting tests are made to assist in determining the quality."

The picture on page 566 shows the kind of package Mr. H. B. Blandford uses in which to pack Osage melons. This illustration also shows how important it is to pack the melons regularly and systematically, rather than in a haphazard way. Climax, or similar makes of baskets, made in different sizes but usually small, are commonly used, in which to pack varieties of small, average size, such as the Rocky Ford. Bushel baskets without covers are frequently used in which to handle melons for local trade.

Whatever the package, it is important to grade to a uniform size and good quality. Melons which have no flavor, or are of decidedly inferior quality, should never be offered for sale. Poor melons have a very depressing effect upon the market demand. When a grower has melons of good quality and grades them properly, he should "brand" the packages in which they are shipped. Selling under a "trade mark" is just as important for the melon grower as for the manufacturer or for any other class of producers.

ANALYSES OF INSECTICIDES AND FUNGICIDES

Special Bulletin No. 96

BY ANDREW J. PATTEN AND E. F. BERGER

The purpose of the insecticide law (Act 254, Public Acts 1913) is to prevent the sale of misbranded or adulterated materials intended for use in "preventing, destroying, repelling or mitigating" insects or fungi that may infest vegetation or "be present in any environment whatsoever." This applies not only to materials used in spraying fruit trees, vegetables, etc., but to all materials or mixtures intended for combating insect pests of all kinds wherever found.

All lice powders, cattle dips, roach exterminators, smut destroyers, etc., come under the requirements of the law.

The law provides that all such compounds or mixtures must bear the name and address of the manufacturer and also the "correct names and percentage amounts of each and every ingredient of the insecticide or fungicide having insecticidal or fungicidal properties and the total percentage of inert ingredients." The law further provides that an article shall be deemed to be misbranded if the package or label under which it is sold "shall bear any statement, design or device regarding such article or the ingredients or substances contained therein that shall be misleading in any particular."

COLLECTION OF SAMPLES

One hundred sixty-eight samples were collected during 1917 and 1918 by official inspectors sent out by the Chemical Section. These samples represent a wide range of materials and, for the most part, were taken in original packages.

During 1917 special attention was given to proprietary smut remedies and formaldehyde solutions. In 1918 our attention was turned particularly to commercial bordeaux and bordeaux-arsenate preparations.

CONCERNING LIME-SULFUR

The use of lime-sulfur solution has now become a fixed part of every fruit-grower's program. Long ago this material passed from the experimental stage and for several years it has been regularly used both as a winter and summer spray.

Within the past few years several attempts have been made to prepare a substitute for the solution that could be put on the market in the dry form. The first of these preparations to appear in the State was "Soluble Sulfur Compound" manufactured by the Niagara Sprayer Co., Middleport, N. Y. This, however, is not a lime and sulfur combination but one of sodium and sulfur. Four samples analyzed during the past two years show an average total sulfur content of 53.39 per cent. The compound is fairly readily soluble in water and for winter spraying should give results comparable with those obtained with ordinary lime-sulfur solution if used in equivalent strength. It cannot safely be used as a summer

spray in combination with lead arsenate, as a soluble arsenate is likely to be formed which will cause burning of the foliage.

Later Sherwin-Williams Co., Cleveland, Ohio, placed on the market a dry lime-sulfur compound. In this preparation, sulfur is combined with lime in the same ratio as it exists in the commercial lime-sulfur solutions. It may be used for both winter and summer spraying. The average of four samples analyzed during the past two years shows 52.42 per cent total sulfur.

Both of these preparations have been widely advertised during the past two or three years and, therefore, demand more than passing notice. The claim is made by the manufacturers that 10 to 14 pounds of these dry preparations dissolved in 50 gallons of water are equivalent to 6¼ gallons of lime-sulfur solution testing 33° Baume. Let us see if these claims hold true.

A barrel, or 50 gallons, of lime-sulfur solution testing 33° Baume weighs approximately 600 pounds and by analysis has been found to contain 26 per cent sulfur and 10.50 per cent lime (CaO). Consequently a barrel of such solution would contain 156 pounds of sulfur and 63 pounds of lime or a total of 219 pounds of dry matter. In other words, a barrel of lime-sulfur solution testing 33° Baume would yield, on evaporation, approximately 219 pounds of dry lime-sulfur. Now 6¼ gallons or one-eighth of the barrel, would contain the equivalent of 27 pounds of dry lime-sulfur. Since the commercial dry lime-sulfur is prepared by first making the solution and then evaporating the water it is not reasonable to believe that a given amount of the dry material will be any more efficient when dissolved in water than it was in the original solution before the water was evaporated.

The process of making the dry sodium-sulfur compound is different from that employed in making the dry lime-sulfur but since it contains practically the same amount of sulfur, the same number of pounds should be used to be equivalent to 6¼ gallons of solution testing 33° Baume.

The preceding comparison is based upon the assumption that the dry preparations will be entirely soluble in water. This, however, is very seldom true especially if the packages have been open for any length of time. In nearly every sample examined we have found a small amount of insoluble residue which was found to be sulfur.

It is now generally recommended that 5½ gallons of 33° Baume lime-sulfur solution be used for dormant spraying. Based upon the analyses of several samples of dry preparations 26 pounds should be used in 50 gallons of water to make a solution of equivalent strength.

The dry preparations made by the Niagara Sprayer Co., and Sherwin-Williams Co., have been taken as examples of the two most common substitutes for lime-sulfur solution. What has been said of them will apply also to the same products made by other companies.

In addition to the preparations referred to in the foregoing discussion, mention should be made of the product known as "B T S" manufactured by the General Chemical Co., New York, N. Y., (formerly Thomsen Chamical Co.). Although none of this has been found in the State it is understood to be a combination of barium and sulfur, and, as in the foregoing cases, its efficiency should be figured on the basis of the total soluble sulfur.

LIME-SULFUR SOLUTIONS AND SOLUBLE SULFUR COMPOUNDS

No.	Manufacturer.	Baume.		Total sulfur.		Calcium poly-sulfide.
		Found.	Guaranteed.	Found.	Guaranteed.	
				%	%	%
136	Hazeltine & Perkins Drug Co., *Grand Rapids, Mich.*	31.6°	....	24.91	....	29.60
158	Imperial Chemical Co., Grand Rapids, Mich.	31.0°	....	24.79	....	29.70
160	San-O-Cide Spray Co., Fennville, Mich.	32.4°	....	25.60	25	30.65
175	South Haven Chemical Co., South Haven, Mich.	32.0°	....	25.75	....	30.34

DRY PREPARATIONS

No.	Manufacturer.	Baume.		Total sulphur.		Sodium poly-sulfide.
		Found.	Guaranteed.	Found.	Guaranteed.	
				%		%
166	Sherwin-Williams Co., Cleveland, Ohio	....	....	52.15	....	58.94
177	Sherwin-Williams Co., Cleveland, *Ohio*	....	....	58.72	....	63.13
322	Sherwin-Williams Co., Cleveland, Ohio	....	....	50.70	....	49.73
320	Sherwin-Williams Co., Cleveland, Ohio	....	....	50.55	....	51.70
415	Detroit White Lead Works, Detroit, Mich.	....	....	63.82	....	70.74

SOLUBLE SULFUR COMPOUNDS (SODIUM POLYSULFIDES)

No.	Name and manufacturer.	Baume.		Total sulfur.		Sodium poly-sulfide.
		Found.	Guaranteed.	Found.	Guaranteed.	
				%		%
128	Sulfocide—B. G. Pratt Co., New York, N. Y.	41.2°	....	36.15	....	44.59
187	Soluble Sulfur Compound—Niagara *Sprayer Co., Middleport, N. Y.*	....	....	54.45	....	48.92
179	Soluble Sulfur Compound—Niagara Sprayer Co., Middleport, N. Y.	....	....	52.70	....	42.17
318	Soluble Sulfur Compound—Niagara Sprayer Co., Middleport, N. Y.	....	....	53.17	....	49.72
344	Soluble Sulfur Compound—Niagara Sprayer Co., Middleport, N. Y.	....	....	53.24	....	55.64

ARSENATES

Arsenate of Lead Paste. Ten samples were collected and analyzed. Only one sample was found to be below the legal standard. Sample 155 manufactured by the Imperial Chemical Co., Grand Rapids, Mich., contained less than the legal amount of total arsenic oxide and more than the legal amount of water and water-soluble arsenic oxide.

Arsenate of Lead Powder. Thirty-one samples were collected and analyzed. There is no legal standard set for dry arsenate of lead but a standard corresponding to the paste form would be as follows: Not less than 25 per cent total arsenic oxide (As_2O_5) and not more than 1.50 per cent water-soluble arsenic oxide (As_2O_5). Sample 149 manufactured by the Imperial Chemical Co., Grand Rapids, Mich., is the only one found to be below the standard for total arsenic oxide and sample 153, manufactured by the Corona Chemical Co., Milwaukee, Wisconsin, is the only one found above the standard for water-soluble arsenic oxide.

Calcium Arsenate. Only two samples of calcium arsenate were found although five samples of calcium arsenate with lead arsenate were secured and analyzed. It is interesting to note that in the samples of calcium arsenate the water-soluble arsenic oxide is greater than 1.50 per cent while in the samples containing an admixture of lead arsenate the amount of water-soluble arsenic oxide, with one exception, is less than one-half of one per cent.

LEAD ARSENATE (PASTE)

No.	Manufacturer.	Moisture.	Lead oxide PbO		Arsenic oxide As_2O_5			
					Total.		Soluble.	
			Found.	Guar.	Found.	Guar.	Found.	Guar.
		%	%	%	%	%	%	%
382	Ansbacher Insecticide Co., New York, New York.....	51.20	31.34	....	15.42	15.00	0.10	0.50
112	Dow Chemical Co., Midland, Mich.....................	50.10	31.75	....	16.27	15.00	0.10	......
161	Dow Chemical Co., Midland, Mich.....................	32.00	63.85	....	22.03	15.00	0.26	0.75
408	Dow Chemical Co., Midland, Mich.....................	48.80	32.25	......	16.97	15.00	0.26	0.75
134	Grasselli Chemical Co., Cleveland, Ohio..........	48.60	33.88	....	16.09	15.00	0.19	....
364	Grasselli Chemical Co., Cleveland, Ohio..........	44.33	31.30	....	17.04	13.50	0.19	0.50
411	Grasselli Chemical Co., Cleveland, Ohio..........	40.20	39.40	....	18.60	15.00	0.19	....
155	Imperial Chemical Co., Grand Rapids, Mich,.....	54.20	32.74	....	10.98	12.50	0.17	1.00
372	Fred L. Lavenburg, New York, N. Y..........	46 29	32 65	....	14 29	....	0.53	....
381	Sherwin-Williams Co., Cleveland, Ohio..............	49.88	36.21	....	12.38	....	0.25	....

LEAD ARSENATE (DRY POWDER)

No.	Manufacturer.	Lead oxide PbO	Arsenic oxide As_2O_5 Total. Found.	Arsenic oxide As_2O_5 Total. Guar.	Arsenic oxide As_2O_5 Soluble. Found.	Arsenic oxide As_2O_5 Soluble. Guar.
		%	%	%	%	%
173	Ansbacher Insecticide Co., New York, N. Y.	65.90	28.50	......	0.61	......
174	Ansbacher Insecticide Co., New York, N. Y.	63.94	31.60	......	0.84	......
369	Albany Chemical Co, Albany, N. Y.	63.55	33.10	30.00	0.42	1.50
153	Corona Chemical Co., Milwaukee, Wis.	60.20	33.67	......	3.81	......
163	Corona Chemical Co., Milwaukee, Wis.	65.00	31.57	30.00	0.31	0.50
171	*Corona Chemical Co., Milwaukee, Wis.*	*67.60*	*28.20*	......	*0.35*	......
111	Corona Chemical Co., Milwaukee, Wis.	65.35	31.90	......	0.17	......
341	Corona Spraying & Dusting Materials, Milwaukee, Wis.	64.15	32.75	30.00	0.27	......
138	Detroit White Lead Works, Detroit, Mich.	64.18	31.45	30.00	0.23	1.00
145	Detroit White Lead Works, Detroit, Mich.	63.92	34.20	......	1.08	......
385	Detroit White Lead Works, Detroit, Mich.	61.85	32.18	30.00	0.38	1.00
182	*DeVoe & Raynolds, Inc., New York, N. Y.*	*66.26*	*29.00*	......	*1.24*	......
183	DeVoe & Raynolds, Inc., New York, N. Y.	66.70	28.50	......	0.71	......
189	DeVoe & Raynonds, Inc., New York, N. Y.	64.46	30.90	......	1.44	......
162	Dow Chemical Co., Midland, Mich.	67.76	29.05	30.00	0.31	......
135	Grasselli Chemical Co., Cleveland, Ohio	66.12	31.28	30.00	0.25	0.65
365	Grasselli Chemical Co., Cleveland, Ohio	64.28	32.30	......	0.27	......
149	Imperial Chemical Co., Grand Rapids	67.06	22.63	......	1.10	......
172	*Imperial Chemical Co., Grand Rapids*	*64.34*	*30.60*	......	*0.35*	......
366	Imperial Chemical Co., Grand Rapids	63.99	30.93	30.00	0.85	1.00
348	Merrimac Chemical Co., Boston, Mass.	62.23	31.87	25.00	0.45	1.50
147	Niagara Sprayer Co., Middleport, N. Y.	64.48	32.25	30.00	0.40	1.00
151	Niagara Sprayer Co., Middleport, N. Y.	63.28	33.95	......	0.10	......
373	Niagara Sprayer Co., Middleport, N. Y.	66.60	29.45	25.00	1.09	1.50
150	Sherwin-Williams Co., Cleveland, Ohio	62.58	32.99	30.00	0.32	1.00
176	*Sherwin-Williams Co., Cleveland, Ohio*	*64.62*	*32.12*	......	*0.31*	......
380	Sherwin-Williams Co., Cleveland, Ohio	64.25	33.30	30.00	0.28	1.00
150	Toledo Rex Spray Co., Toledo, Ohio	65.76	32.30	31.00	0.17	1.00
388	Van The Tool Man, Lansing, Mich.	63.49	31.75	33.00	0.18	0.75
110	Unknown	63.35	33.30	......	0.81	......

CALCIUM ARSENATE AND CALCIUM ARSENATE WITH LEAD ARSENATE

No.	Manufacturer.	Calcium (Ca).	Lead oxide (PbO).	Arsenic oxide As_2O_5 Total. Found.	Arsenic oxide As_2O_5 Total. Guar.	Arsenic oxide As_2O_5 Soluble. Found.	Arsenic oxide As_2O_5 Soluble. Guar.
		%	%	%	%	%	%
317	Niagara Sprayer Co., Middleport, N. Y.	......	......	41.06	42.0	2.55	0.75
333	Niagara Sprayer Co., Middleport, N. Y.	......	......	43.60	......	1.99	......
165	Niagara Sprayer Co., Middleport, N. Y.	15.30	1.96	40.09	......	0.38	......
168	Niagara Sprayer Co., Middleport, N. Y.	15.35	1.68	40.00	......	0.46	......
152	*Riches, Piver & Co., Hoboken, N. J.*	*14.85*	*2.50*	*40.29*	......	*0.09*	......
131	H. J. Smith & Co., Utica, N. Y.	15.20	2.32	18.25	*19.9	2.78	†2.13
327	H. J. Smith & Co., Utica, N. Y.	......	3.15	21.00	*19.9	0.26	†2.13

*Calculated from guarantee of 13% metallic As.
†Calculated from guarantee of 1.4% metallic As.

PARIS GREEN

Only eight samples were collected and analyzed, all of which were found to conform to the legal standards, both as to total and soluble arsenious oxide (As_2O_3).

Two samples of "Bug Finish" manufactured by the Michigan Gypsum Co., Grand Rapids, Michigan, and one sample of "Bug Dope," prepared by H. J. Smith & Co., Utica, New York, are included in the table. These are mixtures of inert materials, such as gypsum, and a small amount of paris green for dusting.

PARIS GREEN

No.	Manufacturer.	Weight.	Arsenious oxide As_2O_3. Total. Found.	Total. Guar.	Soluble. Found	Soluble. Guar.	Copper oxide (CuO).
		Oz.	%	%	%	%	%
376	Corona Chemical Co., Milwaukee, Wis.	15.9	55.65	50.0	2.39	3.50	30.23
361	DeVoe & Raynolds, New York, N. Y.	4.2	55.90	50.0	1.50	3.50	29.92
383	Detroit White Lead Works, Detroit, Mich.	17.3	55.75	......	1.30	......	30.39
157	Imperial Chemical Co., Grand Rapids Mich.	......	55.70	50.0	1.49	3.50	31.36
368	Imperial Chemical Co., Grand Rapids, Mich.	2.1	55.60	50.0	1.70	3.50	30.39
389	Imperial Chemical Co., Grand Rapids, Mich.	4.0	56.30	50.0	1.50	3.50	29.76
349	Fred L. Lavenburg, New York, N. Y.	4.0	56.40	50.0	2.39	3.50	30.23
342	Sherwin - Williams Co., Cleveland Ohio	8.8	55.20	50.0	1.60	3.50	30.86
	BUG FINISH						
324	The Michigan Gypsum Co., Grand Rapids, Mich.	......	0.52	......	......	......	......
193	The Michigan Gypsum Co., Grand Rapids, Mich.	......	0.60	......	......	......	......
	BUG DOPE						
184	H. J. Smith & Co., Utica, N. Y.	......	0.60	......	......	......	......

CONCERNING COMMERCIAL BORDEAUX MIXTURES AND BORDEAUX ARSENATE MIXTURES

During the past few years there have appeared on the market an increasing number of commercial bordeaux and bordeaux arsenate mixtures. The use of these preparations during the past two years was stimulated by the high price and scarcity of copper sulfate. With a return of prices to approximately the pre-war level it may be interesting to compare these commercial products with the home-made preparations. In order to do this it is necessary to take into consideration two factors, namely, the chemical composition and physical condition.

Chemical Composition. The fungicidal value of bordeaux mixture is due to the presence of copper. The strength of homemade solutions is

usually expressed in terms of crystallized copper sulfate or blue vitriol. The formula most commonly used is 4-4-50 meaning 4 pounds each of crystallized copper sulfate and quick lime and 50 gallons of water.

The State and Federal insecticide laws require the strength of commercial bordeaux to be expressed in terms of metallic copper. This means little to the person who is unfamiliar with the chemical relationships involved. When the strength of the commercial bordeaux mixture is expressed as metallic copper the equivalent amount of crystallized copper sulfate (blue vitriol) may be quickly obtained by multiplying the percentage of metallic copper (Cu) by the factor 3.93. If the strength is expressed as copper oxide (CuO) or copper hydroxide ($Cu(OH)_2$) multiply by the factors 3.14 and 2.56 respectively. The result obtained will represent the amount of crystallized copper sulfate equivalent to guaranteed percentage of copper in the various forms as expressed on the label. To calculate the amount of copper sulfate in the spray mixture when diluted and ready for application, multiply the percentage of copper sulfate as found by the number of pounds of the concentrated bordeaux mixture to be added to 50 gallons of water.

The following example will serve to illustrate the process as outlined. A sample of commercial bordeaux mixture, found on the market, was guaranteed to contain 7.50 per cent copper (Cu), which, multiplied by the factor 3.93 equals 29.48 per cent crystallized copper sulfate. One pound of the preparation, therefore, would contain 0.2948 pounds of crystallized copper sulfate. The label recommends that 8 pounds of the mixture be diluted to 50 gallons with water. The amount of crystallized copper sulfate in the 50 gallons of diluted spray mixture is found by multiplying 0.2948 by 8 which equals 2.16 pounds.

This particular bordeaux mixture, when diluted according to directions, would give a spray mixture a trifle stronger than a 2-2-50 formula.

Knowing the price of crystallized copper sulfate and quick lime at any given point the actual money value of the commercial mixtures can easily be calculated. This, of course, will vary in different localities owing to variations in the prices of the raw materials.

Physical Condition. The second factor in determining the value of commercial bordeaux mixtures is their physical condition. This condition determines the spreading and sticking properties of the mixture and is measured by the rate at which the suspended material settles. A well made bordeaux mixture, will, upon dilution, remain in suspension a long time but some of the commercial preparations will settle almost immediately. The commercial preparations will be found to vary considerably in this characteristic. Before buying any quantity of commercial bordeaux this test should be applied to a small sample. In making this test the dilution should be made in the same proportion as recommended on the label for preparing the material for spraying.

HOW TO CALCULATE THE STRENGTH OF BORDEAUX-LEAD ARSENATE MIXTURE

In materials of this kind the law requires the manufacturer to guarantee the amount of lead arsenate both total and water-soluble in terms of metallic arsenic (As). In order to convert this into lead arsenate (dry

form) it is necessary to multiply by the factor 6. If the amount of lead arsenate is expressed in terms of arsenic oxide (As_2O_5) then it is necessary to multiply by the factor 3.93.

Example. A sample of Bordeaux-Lead Arsenate was guaranteed by the manufacturer to contain 1.50 per cent copper (Cu) and 5.25 per cent arsenic oxide (As_2O_5). Using the method already described we find that the mixture should contain 5.90 per cent crystallized copper sulfate (1.50 x 3.93=5.90) and 20.64 per cent lead arsenate (5.25 x 3.93=20.64). The manufacturers recommend that 8 pounds of this particular material be diluted with water to 50 gallons. Therefore, when ready for spraying the 50 gallons would contain 0.47 pound of crystallized copper sulfate (0.059 x 8=0.47) and 1.65 pounds of lead arsenate (0.2064 x 8=1.65). The equivalent amount of lead arsenate paste is approximately double that of the dry form.

As previously stated the formula most generally recommended for making bordeaux is 4-4-50 though for some purposes a 2-2-50 formula may be used. When it is desired to combine an insecticide with the fungicide lead arsenate is usually employed at the rate of 2 to 5 pounds of the paste or 1 to 2½ pounds of the dry powder to 50 gallons of the diluted bordeaux mixture.

As a general rule it will be found that the commercial bordeaux-arsenate preparations do not contain the essential ingredients in the proportions that have been found by practice to give the best results. The poison is usually greatly in excess of the fungicide and when used according to the usual recommendations of the manufacturers the preparations could hardly be expected to possess very powerful fungicidal powers.

BORDEAUX MIXTURES

No.	Manufacturer.	Water.	Copper (Cu).	
			Found.	Guar.
	PASTE.	%	%	%
144	Grasselli Chemical Co., Cleveland, Ohio	61.50	7.81	7.50
181	Grasselli Chemical Co., Cleveland, Ohio	61.50	7.57	7.50
410	Grasselli Chemical Co., Cleveland, Ohio	50.40	9.07	7.50
126	Hammond Paint & Slug Shot Works, Beacon, N. J.	53.50	6.76	5.50
371	*Imperial Chemical Co., Grand Rapids, Mich.*	*68.12*	*6.14*	......
156	Imperial Chemical Co., Grand Rapids, Mich.	51.50	9.61	6.00
180	Nitrate Agencies Co., New York N. Y.	58.70	6.27	6.00
	DRY POWDERS.			
190	Corona Chemical Co., Milwaukee, Wis.	......	10.48	......
367	*Imperial Chemical Co., Grand Rapids, Mich.*	......	*9.76*	*11.00*
185	Sherwin-Williams Co., Cleveland, Ohio, "Fungi Bordo"	......	10.65	......
186	Sherwin-Williams Co., Cleveland, Ohio, "Fungi Bordo"	......	10.20	......

BORDEAUX-ARSENATE MIXTURES

No.	Manufacturer and name.	Water.	Arsenic (As) Total.		Arsenic (As) Soluble.		Copper (Cu)		Lead oxide (PbO)
			Found.	Guar.	Found.	Guar.	Found.	Guar.	
		%	%	%	%	%	%	%	%
	Ansbacher Insecticide Co., New York, N. Y.								
326	"Adheso Green Label"	59.61	6.03	5.50	0.15	....	3.96	4.00	17.00
169	"Adheso Green Label"	57.50	6.68	5.50	0.12	....	3.85	4.00	20.70
194	"Adheso Green Label"	64.30	5.48	5.50	0.09	....	2.46	4.00	17.30
319	"Adheso Orange Label"	56.79	7.09	5.75	0.07	0.50	2.69	2.80	15.36
195	"Adheso Orange Label"	53.90	6.85	5.75	0.13	0.50	4.10	2.80	19.10
170	"Adheso Orange Label	63.50	5.86	5.75	0.15	0.50	2.52	2.80	18.20
	Bowker Insecticide Co., Boston, Mass.:								
409	"Pyrox"	60.90	5.17	3.42	0.04	....	3.19	1.50	9.15
188	"Pyrox"	64.40	4.17	3.42	0.09	....	3.13	1.50	16.60
	DRY POWDERS.								
	Detroit White Lead Works, Detroit, Mich.:								
139	"Rogers Leaded-Bordo"	.....	11.61	12.00	0.08	0.50	3.60	4.00	39.90
414	"Rogers Leaded-Bordo"	....	12.48	12.00	0.11	0.50	3.95	....	36.52
413	"Rogers Potato Spray"	....	22.30	24.00	1.50	3.00	20.63	....	....
	Sherwin-Williams Co., Cleveland, Ohio:								
312	"Tuber Tonic"	....	24.55	24.00	1.63	3.00	21.71	....	....
323	"Tuber Tonic"	....	25.43	24.00	1.51	3.00	22.02	....	....
154	"Tuber-Tonic"	....	22.49	....	0.57	....	21.48	....	....
191	"Tuber-Tonic"	....	19.21	24.00	2.53	3.00	23.18	....	....
192	"Insecto Powder	....	12.01	....	0.09	....	3.15	....	37.60

TOBACCO PRODUCTS

Eleven samples of tobacco products were analyzed, all of which, with one exception, were equal to or exceeded the guarantee for nicotine.

No.	Manufacturer.	Nicotine. Found.	Nicotine. Guar.
		%	%
	Carpenter-Udell Chemical Co., Grand Rapids, Mich.:		
315	"*Imperial Nicotine Solution*"	9.59	10.00
	Grasselli Chemical Co., Cleveland Ohio:		
332	"Sulfate of Nicotine"	16.41	15.00
	Imperial Chemical Co., Grand Rapids, Mich.:		
330	"Imperial Nictine 40%"	40.18	40.00
	Kentucky Tobacco Products Co., Louisville, Ky.:		
133	"Black Leaf 40"	40.03	40.00
146	"Black Leaf 40"	39.91	40.00
314	"Black Leaf 40"	40.41	40.00
328	"Nico-Fume Liquid"	39.91	40.00
125	"Nico-Fume Liquid"	40.11	40.00
	Sterling Chemical Co., Cambridge, Mass.:		
313	"Sterlingworth Powdered Tobacco"	0.63	....
	F. A. Thompson & Co., Detroit, Mich.:		
329	"Rose Nicotine"	10.32	10.00
132	"Rose Nicotine"	10.47	10.00

SMUT REMEDIES AND FORMALDEHYDE SOLUTIONS

Special attention was given to these preparations during 1917. Several proprietary compounds were on sale in the State in violation of the insecticide law in that they were not labelled so as to show the active ingredients. All of these preparations were found to be, essentially, solutions of formaldehyde (formalin) to which had been added, in some cases, coloring matter or one or more of such materials as carbolic acid, copper sulfate, aloes, pix liquida, sodium hydrate, green soap, etc.

The claim was made that the addition of these materials increased the efficiency of the formalin. However since the formalin treatment when properly conducted is practically 100 per cent efficient it is difficult to understand how this could be much improved.

The attention of the various manufacturers was called to the requirements of the law in regard to the labelling and it appears that they are all now complying with the law or have gone out of business.

Sixteen samples of formaldehyde solution (formalin) which was being sold for grain treatment were collected. Very few of these were properly labelled and the dealers were notified to comply with the law in this respect. The names of the manufacturers of the various samples could not be obtained and in the following table the dealer's name is given.

The solution of formaldehyde is usually sold under the trade name, *formalin,* and is supposed to be of 40 per cent strength. This generally means 40 per cent by volume which corresponds to 36.8 per cent by weight. The results in the following table are given in per cent by weight.

Eight of the samples were found to contain more than 36 per cent of formaldehyde and four samples contained more than 35 per cent but less than 36 per cent formaldehyde. Two samples were less than 34 and more than 32 per cent formaldehyde while two contained less than 30 per cent. There is probably no very great difference in efficiency between formaldehyde solutions of 35 and 36 per cent formaldehyde but as between 36 and 30 per cent there would be considerable loss of efficiency.

SMUT REMEDIES (FORMALDEHYDE SOLUTIONS)

No.	Manufacturer or dealer and name.	Formaldehyde.	
		Found.	Guar.
	Anti Smut Chemical Co., North Adams, Mich.:	%	%
335	"Anti-Smut"	26.87	35.00
114	"Anti-Smut"	26.90	......
	Dr. Lape Veterinary Co., Inc., Adrian, Mich:		
336	"Dr. Lape's Smut Destroyer"	31.85	18.00
140	"Dr. Lape's Smut Destroyer"	33.15	......
337	"Smutene"	33.65	......
122	"Smutene"	32.75	35.00
	Smut Cure Chemical Co., Saline, Mich.:		
363	"Smut Kure"	*31.25	......
	Chemical Research Co., Kalamazoo, Mich.:		
357	"The Original Smut Killer"	30.05	......
196	"The Original Smut Killer"	26.20	
	Manufacturer unknown, Atlanta, N. Y.:		
406	"Sporocide"	36.25	......
390	"Formalin" sold by C. E. Nelson, Coopersville	35.85	......
391	"Formalin" sold by Hazeltine & Perkins, Grand Rapids	35.50	......
392	"Formalin" sold by W. H. Quigley, Grand Rapids	28.50	......
393	"Formalin" sold by J. Gezon, Grand Rapids	36.55	......
394	"Formalin" sold by A. De Kruif, Zeeland	36.86	......
395	"Formalin" sold by H. J. Fisher, Holland	32.14	......
396	"Formalin" sold by Haan Bros., Holland	36.12	......
397	"Formalin" sold by Brundage Drug Store, Muskegon	35.71	......
398	"Formalin" sold by Bolender's Pharmacy, Sparta	36.71	......
399	"Formalin" sold by E. A. Webb, Casnovia	36.89	......
400	"Formalin" sold by J. T. Perham, Kent City	33.23	......
401	"Formalin" sold by Lewis H. Cooper, Fowlerville	36.96	......
402	"Formalin" sold by Cowdrey's Drug Store, Howell	36.70	......
403	"Formalin" sold by Phelp's Drug Store, Hudson	35.53	......
404	"Formalin" sold by Benfer & Nachtereib, Adrian	36.14	......
405	"Formalin" sold by A. O. Dersham, Blissfield	29.92	......

*Also contains 1.86 per cent crystallized copper sulfate.

LICE POWDERS

Fifteen samples of lice powder were collected. These were found to be mixtures of two or more of the following materials with an inert ingredient as a base: nicotine, sulfur, naphthaline, pyrethrum.

No.	Manufacturer	Nicotine		Sulfur.		Naphthalin.	Pyrethrum.
		Found.	Guar.	Found.	Guar.		
	G. E. Conkey & Co., Cleveland, Ohio:	%	%	%	%		
347	"Conkey's Lice Powder"........	0.27	0.10	16.91	15.85	....	....
	Cyphers Incubator Co., Buffalo, N. Y.:						
360	"Cypher's Lice Powder"........	0.61	0.50	4.75	4.60	Present	....
	The Feil Mfg. Co., Cleveland, Ohio:						
343	"Salvet Lice Powder"........	Trace	....	41.71	....	....	....
	J. J. Fleck, Tiffin, Ohio:						
141	"Fleck's Lice Powder"........	0.01	0.01	....	....	Present	Present
	Dr. Hess & Clark, Ashland, Ohio:						
117	Dr. Hess' Instant Louse Killer........	Trace	....	....	....	Present	....
	International Stock Food Co., Minneapolis, Minn.:						
118	International Louse Killer........	....	....	3.75	3.00	Present	....
	Jones The Seed Man, Grand Rapids:						
120	"Jones Lice Powder"........	0.41	0.25	8.90	9.00	Present	....
	Dr. Lape Veterinary Co., Adrian:						
338	"Dr. Lape's Lice Killer"........	....	....	63.00	....	....	....
	Geo H. Lee Co, Omaha, Neb.:						
346	"Lee's Louse Powder"........	....	....	72.35	....	Present	Present
	Dr. L. D. LeGear, Medicine Co., St. Louis, Mo.:						
345	"Dr. LeGear's Lice Killer"........	0.29	0.24	20.85	30.0	....	....
	Pratt Food Co., Chicago, Ill.:						
350	"Pratt's Lice Killer"........	0.90	....	....	....	Present	Present
119	"Pratt's Lice Killer"........	0.42	0.34	....	....	Present	Present
	Wm. Rust & Sons, New Brunswick, N. J.						
358	"Rust's Lice Killing Powder"........	0.76	0.40	9.35	7.50	....	....
	Dr. David Roberts Veterinary Co., Waukesha, Wis.:						
353	"Diolice"........	0.14	0.15	26.63	23.00	Present	....
	Zenner Disinfectant Co., Detroit:						
340	"Zenoleum Lice Powder"........	0.46	0.25	10.90	10.00	Present	....

COAL TAR DIPS AND DISINFECTANTS

These preparations form emulsions when mixed with water and are generally prepared by mixing together, with gentle heating, a mineral oil containing phenol (crude carbolic acid) and rosin soap or a mixture of rosin and vegetable soaps.

These preparations are used in the west as sheep dips and in some sections as a spray for scale. They are also used more or less extensively as lice killers and as disinfectants. The value of these products for the above purposes is chiefly, though not entirely, due to the amount of phenol present. A glance at the following table will show how greatly they vary with respect to the amount of phenol.

No.	Manufacturer.	Hydro-carbons.	Pyri-dene bases.	Rosin acids.	Phenol.
	Geo. E. Conkey Co., Cleveland, Ohio:	%	%	%	%
124	"Conkey's Nox-I-Cide"	62.50	2.72	18.20	9.50
116	"Conkey's Lice Liquid"	69.90	2.53	13.20	3.90
	Dr. Hess & Clark, Ashland, Ohio:				
339	"Dr. Hess Dip & Disinfectant"	49.70	2.09	15.50	14.70
	Geo. H. Lee Co., Omaha, Neb.:				
115	"Lee's Lice Killer	85.00	....	....	2.50
	Wm. Rust & Sons Co., New Brunswick, N. J.:				
359	"Rust's Mite Killer"	73 40	3.53	....	9.75
	United Breeder Co., Chicago, Ill.:				
356	"Kill Gem Dip"	46.60	2.31	14.90	18.40
	The Zenner Disinfectant Co., Detroit:				
137	"Zenoleum"	80.10	3.20	10.90	4.00

MISCELLANEOUS MATERIALS

379, 353, 127, 143 Bug Death. Manufactured by Danforth Chemical Co., Leominster, Mass. Guaranteed to contain Zinc Oxide 47%, Lead Oxide 5%. Results found:

Number.	Zinc oxide %	Lead oxide %
379	61.28	3.74
352	45.89	9.89
127	44.58	12.69
143	55.60	11.56

384, 370, 113 Hammond's Slug Shot. Manufactured by Hammond Slug Shot Works, Beacon, N. Y. Guaranteed to contain Sulfur 6% Copper Sulfate, 1%, Nicotine trace, Copper Arsenite, 1.50% Crude Carbolic Acid 40%, Inert ingredients 91%. Results found:

Number.	Nicotine.	Sulfur. %	Arsenic Metallic. %	Copper.
384	Present...	6.13	0.98	Present
370	Present...	5.05	1.00	Present
113	Trace....	5.65	1.21	Present

321 Herman's Calite. Manufactured by Morris Herrmann & Co., New York, N. Y.

Found—Water, 69.20%, Total Arsenic, 11.57%;
Soluble Arsenic, 0.53%.
Sample is Calcium Arsenate Paste.

362 London Purple. Manufactured by Hemmingway's London Purple Co., New York, N. Y.
Found—Total Arsenic, 29.52%; Soluble Arsenic, 9.91%.
Sample consists of Calcium Arsenite, 23.82% and Calcium arsenate, 40.81%.

378 Nichols Bed Bug Powder. Manufactured by Chas. H. Nichols & Co., Chicago, Illinois.
Guaranteed to contain Quassia, Angelica root, Eucalptus leaves, Colocynith and Borax.
Found Sodium Borate, 16.61%.

377 Rose Nicotine for Roaches. Manufactured by F. A. Thompson & Co., Detroit, Michigan.
Contains 89.90% Sodium Fluoride, small amount of Sugar and Salt.

142 Bug-i-cide. Manufactured by Barrett Chemical Co., Chicago, Illinois.
Distills between 45°-140° C. It is composed of kerosene and light oils and contains red coloring matter.

351 Peterman's Discovery. Manufactured by Wm. Peterman, Inc., New York, N. Y.
Yellow colored liquid. Specific gravity at 21° C. 0.787.
Flash point 47° C. Tests indicate kerosene.

354 "Dead Stuck." Manufactured by The Penn Chemical Mfg. Co., Philadelphia, Penn.
Orange colored liquid. Specific Gravity at 20° C. 0.7415.
Distillation:
70°-100° C. 4 per cent, odor of gasoline
100°-130° C. 64 per cent
130°-180° C. 28 per cent, Flash point 50° C.
Vapor of original solution will ignite at room temperature.
A mixture of gasoline and kerosene.

374 A. D. S. Bug Killer. Manufactured by American Druggists Syndicate, Grand Rapids, Mich.
Red solution. Specific gravity at 21° C. 0.799.
Flash point 48° C. Distilled between 150° and 220° C. Has properties of kerosene.

375 Xtermolene. Manufactured by R. M. Hollingshead, Camden, N. J.
Green liquid. Specific gravity at 21° C. 0.795.
Flash point 55°. Has properties of kerosene.

384 Sterlingworth Plant Lice Killer. Manufactured by Sterling Chemical Co., Cambridge, Mass.
Contains 44.9% kerosene.

121 Deth-Ant. Manufactured by Grand Rapids Lawn Ant Destroyer, Grand Rapids, Mich.
Specific gravity, 1.25.
Sample is carbon-di-sulfid with red coloring matter.

355 Standard Fly Shy. Manufactured by Standard Chemical Mfg. Co., Omaha, Neb.
Specific gravity 0.959.
Distillation:

Temperature range.	Amount distilled. %	Specific gravity. %	Color.
190°–215° C	15	0.769	Yellowish
215°–233° C	8	0.910	Yellowish
233°–260° C	16.5	0.930	Yellowish
260°–280° C	8.5	0.953	Yellowish
280°–305° C	12.5	0.950	Yellowish
305°–330° C	11.5	0.953	Light orange
330°–360° C	11.0	....	Deep orange
360° C	11.0	0.974	Red orange

412 Sterlingworth Whale Oil Soap Kerosene Emulsion. Manufactured by Sterling Chemical Co., Cambridge, Mass.

Contains 51.2% kerosene.

129 Hammond's Thrip Juice. *Manufactured by* Hammond's Slug Shot Works, Beacon, N. Y.

Rosin and Soap 43.40%, Nicotine 0.92%, Potash 7.75%.

334 *Spray-No-More "Tree Tablets."* For removing San Jose scale and Black Knot from Trees. "Used any season of the year, the sooner the better."

Manufactured by Spray-No-More Co., Ford Market Bldg., Highland Park, Mich.

The user is directed to bore a hole in each main branch, on the upper surface, and insert a tablet. The hole is then to be closed by a plug cut from the same tree.

Results of analysis:

Ash, 5.50 per cent.

Ether extract, 2.38 per cent.

Color of ether extract, dark green with strong smell of pyrethrum.

The analysis indicates that the tablets are composed very largely of pyrethrum.

Bitler's Red Line Tree Life. "For trees, shrubs and plants. A preparation containing:

Not over 1.70 per cent arsenic
Not over 0.60 per cent copper
Not over 2.00 per cent sulfur
Not over 10.00 per cent calcium oxide."

Manufactured and guaranteed by W. A. Bitler, Kokomo, Ind.

This product was offered for sale in a very limited way during 1917.

An analysis of the product gave the following results:

Water	71.60 per cent
Calcium Oxide (CaO)	9.70 per cent
Magnesium Oxide (MgO)	5.56 per cent
Sulfur (S)	1.96 per cent
Lead Oxide (PbO)	1.45 per cent
Arsenious Oxide (As_2O_3)	0.75 per cent
Arsenic Oxide (As_2O_5)	1.83 per cent
Iron and Aluminum (Fe_2O_3-Al_2O_3)	1.20 per cent
Carbon dioxide (CO_2)	1.41 per cent
Copper	Present

The preparation appears to be a mixture of lime, sulfur, bordeaux mixture, lead arsenate, and possibly paris green with water.

Misbranding of the article was alleged in that it was an insecticide and fungicide, the label of which bore statements that were false and misleading. *The Michigan distributor was, therefore, directed to discontinue the* sale of the preparation.

ALFALFA IN MICHIGAN

Special Bulletin No. 97

J. F. COX, PROFESSOR OF FARM CROPS

During the past twenty years alfalfa has commanded more interest in Michigan in proportion to the acreage grown than any other forage crop.

At the present time those who have had experience with growing it are fairly well divided into two classes. One is the enthusiastic group made up of those who have worked out successful methods of handling this crop, and who have grown alfalfa under adapted conditions. These are inclined to speak in glowing terms of the high yield of hay secured, its superiority for feeding purposes and the value of alfalfa in improving the land.

The other, the doubtful or pessimistic group, is composed of those who have not made a success with alfalfa or who have planted it under conditions not suited to its growth. They are often equally emphatic in stating that alfalfa cannot be considered as a dependable crop for Michigan.

Through the experience of those who have succeeded and those who have failed in alfalfa growing, the production of alfalfa has at the present time become fairly well stabilized. Its acreage is increasing steadily but slowly each year. It is estimated that about 80,000 acres were seeded in this State in 1918. The success of this crop rightly handled, and the *value of alfalfa hay as a feed has been demonstrated to the extent that* it is apparent that a much greater acreage of alfalfa is warranted in Michigan.

Successful crops may be found growing on soils ranging in texture from light sands, light enough to blow, to heavy clays which work with difficulty. *Good drainage is a characteristic of all soils where thrifty* alfalfa is found.

Alfalfa fields may be found well distributed throughout the southern peninsula and in certain of the more developed upper peninsula counties. This crop is of greater value in the older farming sections and has no great place at present in newly cleared sections of northern Michigan where June grass comes in with surprising vigor and clover is easily secured.

Experience has shown that ordinary methods of culture which may give good results with our better known forage crops, cannot be depended upon to give successful results with alfalfa, but if the requirements and culture of this crop are thoroughly understood, dependable and profitable returns may be secured under a wide variety of soil and climatic conditions.

While a comparatively few farmers located on favorable soils may secure a good stand with little effort, *it is necessary for the majority*

who wish to grow alfalfa to understand the requirements of this crop and make proper preparations before seeding.

Increase in the production of alfalfa will be largely in proportion to the spread of accurate information regarding the proper handling of this crop. An increased alfalfa acreage will insure the production and increase the yield of leguminous hay so necessary in feeding economically.

LESSONS FROM ALFALFA GROWERS.

A study of the methods followed by those who have succeeded with alfalfa establishes the fact that the successful growers have seeded on sufficiently well-drained land, properly inoculated, have applied lime in some form in sufficient quantity or have planted on land high in calcium carbonate (lime) and have seeded hardy varieties.

In the case of those who have failed, inquiry will bring out the fact that no lime was used, or an insufficient amount, inoculation neglected, soil improperly prepared, inferior or unadapted seed planted, or that exceptionally adverse weather conditions prevailed after planting, or poorly drained soils were selected to receive this deep-rooted crop.

Those who will inform themselves thoroughly concerning alfalfa, and make the necessary preparation may hope to secure returns approaching the claims of the alfalfa enthusiast but it is equally true that to neglect any of the essential points in alfalfa production invites disaster.

SOIL FOR ALFALFA.

The best fields of alfalfa in Michigan are located on well-drained fertile loams and clay loams, though many excellent fields may be found on light sandy and gravelly soils. Good drainage is of the utmost importance, and equally important is the calcium carbonate content. On very heavy soils and muck soils alfalfa often heaves badly during the winter, and unless tile-drained, good stands cannot be retained on these soils.

Only soils which contain limestone pebbles, or which are known to be high in lime may be safely seeded to alfalfa without liming. While fields of a smooth contour are best adapted from a hay-making standpoint, one of the advantages of alfalfa is that good returns can often be secured from rough land. It is difficult to get a stand on soils deficient in organic matter and the growing of green manure crops or application of a dressing of manure may be necessary. Once established, alfalfa will grow vigorously under such conditions much to the improvement of the land.

LIMING THE LAND FOR ALFALFA.

Attempts to secure a successful stand of alfalfa without applying ground lime, stone, marl, beet factory lime, or some form of agricultural lime in sufficient amounts on soils needing lime, are almost sure to result in costly failures. Only on these soils where limestone gravel is noticeable, or where an ample amount of calcium carbonate is assured should alfalfa be attempted without lime.

Applications of lime should be made the year previous to planting alfalfa if possible, or if not, at the time of preparing the seed bed. Two tons of ground limestone, or several cubic yards of marl, or beet factory lime, or one and one-half tons of hydrated lime is recommended. Finely ground limestone can be secured in quantity at all points reached by rail in Michigan. Marl can be found in large deposits in most Michigan lake regions, and where it can be conveniently dug out and hauled it furnishes an excellent supply of effective calcium carbonate for use in applying previous to seeding alfalfa. Neighborhood cooperation in buying ground limestone by the carload, or in getting marl in quantity will greatly lessen the cost of liming.

The practice of digging out sufficient marl in the fall when the water level is low, throwing it up on firm land, or bringing under cover, is an economical and practical way of obtaining a supply in condition for easy application. The marl drains and mellows under winter action, and can be applied with lime-spreader or manure-spreader or shovelled from wagon during late winter or early spring. Michigan Experiment Station Bulletin No. 91, by Professor M. M. McCool, gives complete information on liming the land, and can be secured on request from Director R. S. Shaw, Experiment Station, East Lansing, Michigan.

PHOSPHATES GIVE GOOD RETURNS.

Phosphates give excellent returns when applied to alfalfa, either at time of planting or as a top dressing. The effect of phosphorus is much greater on properly limed land. From 200 to 250 pounds of acid phosphate, acidulated bone meal, or ammoniated phosphate or 800 to 1,000 pounds of finely ground raw rock phosphate or floats will give valuable returns in increased yields. The majority of Michigan soils are deficient in phosphorus and applications of fertilizers carrying this element not only benefit the alfalfa but markedly improve the following crops. A discussion of the use of phosphorus on Michigan soils is given in Popular Bulletin No. 284, Michigan Agricultural Experiment Station.

THE PREPARATION OF THE LAND FOR ALFALFA.

Alfalfa seed starts best on a firm seed bed. Cultivated crops such as corn, beans, potatoes or beets usually leave the land in a clean condition readily shaped for alfalfa.

If the land is not sufficiently free from weeds and grass, fall or early spring plowing is necessary and frequent use of the disc or spring-tooth or spike-tooth harrow at intervals of a week or ten days until weeds and grasses are conquered is advisable. If the ground is clean, thorough discing is sufficient. Just before seeding, the land should be rolled so as to compact firmly. On soils which are deficient in organic matter, applications of well-rotted manure in sufficient amounts should be made, or the content of humus increased by turning under clover, vetch and rye, sweet clover or other green manuring crop.

Alfalfa seed starts best in a firm clean seed bed. A mellow seed bed must be firmly compacted with the roller.

PLANTING ALFALFA.

While the best and most persistent stands of alfalfa are secured by seeding alone without a companion crop, on cultivated lands free from weeds and grass, it has been demonstrated in numerous instances that on soils of average fertility, if well-drained and free from weeds and grasses, successful stands of alfalfa may be secured by seeding in the spring with barley, oats or buckwheat and occasionally with wheat or rye. A better growth of alfalfa will be secured by using only one bushel, or less of barley or oats per acre, or of fall seeded grain, or one peck of buckwheat. On light soils inclined to blow a half bushel of barley, oats or spring rye or one peck of buckwheat seeded as a companion crop will prevent injury from blowing sand. Barley is best suited as

a companion crop for alfalfa since it requires less moisture per pound of dry matter produced than any other grain crop. It must be kept in mind that growing with spring grains at average rates of seeding will hinder rather than help alfalfa, and that it is in spite of the companion crop rather than because of it that good stands are secured when planted with these improperly termed "nurse crops." During dry seasons, cutting oats or barley early for hay will greatly benefit the alfalfa seeding. A light seeding of grains made with early spring planting may be of greater benefit, however, than weed growth which is likely to occur on seed beds not thoroughly clean.

Best results can often be secured, though at somewhat greater expense, by working the seed bed thoroughly until late May or early June, and planting without a companion crop. If ground is very weedy or grassy it may be advisable to continue discing and harrowing until late June or mid-July, seeding only when seed bed is fairly free of these pests. Since alfalfa will occupy the land for from four to six years or more, greater expense and time is warranted in preparation than in the case of annual crops. In southern Michigan seedings are made as late as early August, but experiments show that the latter part of July is about the latest date when seedings can be made with safety. In north central and northern Michigan seedings should not be made later than early July.

Experiments on the Station Plats at East Lansing to determine the effect of seeding at various times with various companion crops has indicated that, while successful results can be secured with companion crops, slightly better stands are secured by seeding alfalfa alone.

Early spring seedings after cultivated crops, either with or without companion crops, have the advantage of an assured supply of moisture for early growth. Seedings made in summer give ample time for thorough preparation of the seed bed.

SEEDING ALFALFA AFTER EARLY CASH CROPS.

Such crops as early potatoes, sweet corn and canning peas usually leave the land in excellent condition for seeding alfalfa. After early potatoes the land should be harrowed and rolled before seeding. After peas and sweetcorn the land can be prepared best by discing. If these crops are harvested before late July, alfalfa may be planted with a fair degree of safety. A good return may be secured from the land, and alfalfa seeded the same season.

Seedings made in early spring with peas at time of planting are also frequently successful. The practice of seeding in standing corn at last cultivation is usually unsatisfactory, but in years when rainfall is plentiful after seeding and autumn is favorable, good stands may result.

Vetch seeded at rate of 10 or 15 pounds at time of seeding alfalfa will give a much greater first cutting than alfalfa alone. The vetch disappears after the first cutting.

SEEDING IN PASTURE MIXTURES.

It is a good practice to include a pound or so of *inoculated alfalfa seed* in all pasture and meadow seedings. The value of the pasture is increased and the presence of occasional vigorous plants in following years indicate the areas of fields adapted to alfalfa, and will aid in insuring thorough inoculation of these areas, so that when seeded entirely to alfalfa, the soil will carry the proper bacteria for nodule formulation.

THE RATE OF SEEDING.

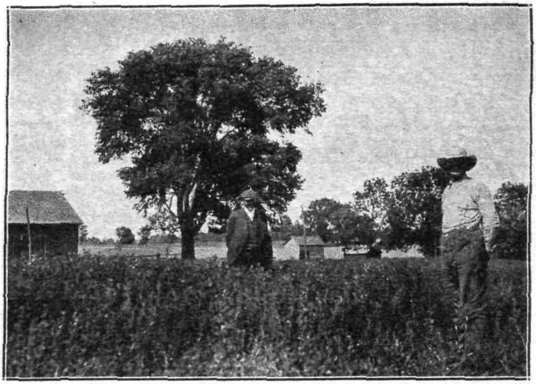
The amount of seed which has given success ranges from ten to twenty pounds per acre. Where planted under excellent conditions if seed is of high germination, ten to twelve pounds will give a sufficient stand. Since these conditions cannot always be secured it is usually advisable to use fifteen pounds per acre.

THE SEED TO PLANT.

The varieties, or strains of alfalfa best adapted to Michigan are variegated strains such as the Grimm, Baltic and Cossack. Regional strains of common alfalfa which have produced seed for a number of years in northern states or regions of similar climatic conditions rank next in value. The U. S. imports annually a large amount of Turkestan seed. Plants from this seed are extremely short lived under Michigan conditions. Fortunately, this seed is characterized by the appearance of the white seeds of the Russian nap weed, a tooth-shaped seed somewhat larger than alfalfa seed, and chalky white in color which makes it easily recognizable. *Such seed does not prove successful in Michigan. Peruvian and Arabian seed is imported in considerable amounts, chiefly for growing in southern California and the Gulf States.* This seed produces plants which are adapted only to mild climates and which are short-lived under our conditions.

At the present time there is not sufficient Grimm, Baltic, and Cossack alfalfa produced to supply the market demands. A large part of the alfalfa planted in Michigan must be common alfalfa, produced in the United States. Those ordering seed should insist on knowing the locality in which it was produced, and should secure American grown seed, preferably from the northwest or grown no farther south than Kansas.

The variegated strains such as Grimm, Baltic and Cossack are characterized by closely set and branching crowns, and by greater development of roots with a tendency toward branching. This type of crown



Alfalfa on farm of Mr. John Hull of Dimondale, showing difference between Grimm and Common Alfalfa. County Agent, Farrand (left) standing in the Grimm and Mr. Hull (right) standing at the edge of it, but in the common alfalfa. Picture taken June 8, 1918, by Dr. Eben Mumford.

and root does not heave or winter-kill as badly as the straighter rooted and higher crowned common alfalfa.

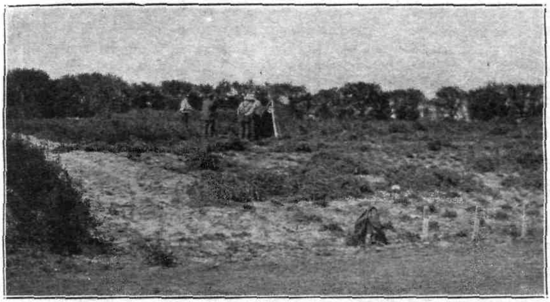
These variegated strains are crosses of the ordinary purple flowered alfalfa (Medicago sativa) and the hardier, though smaller yellow-flowered sickle alfalfa (Medicago fae cata). A variety of colors, purple cream, yellowish, etc., appears in the bloom. Common alfalfa is purple or blue flowered.

The great advantage in northern strains is not always apparent during the first or second year, but usually shows markedly in the superior yield produced from these strains during subsequent years.

Seedsmen are already quoting prices on Michigan grown seed, and report the production in Michigan of between one hundred and two hundred bushels in 1918. While this is a small start, the fact is demonstrated that the production of alfalfa seed is possible commercially under our conditions.

The work of Plant Breeder, F. A. Spragg, Michigan Agricultural College, has demonstrated that large yields of seed can be secured with fair dependability under Michigan conditions, and indicates that there are great possibilities in the development of seed producing strains, particularly on light soils.

As a general rule, the second crop is taken for seed. One of the chief reasons why seed production has not been more extensive is that most farmers growing alfalfa prefer to secure the second crop for hay with a chance for a third crop. If allowed to go to seed the second cutting, and usually the third is lost for hay purposes. A yield, however, of



Harvesting alfalfa nursery at M. A. C. Plant Breeder F. A. Spragg has developed several promising seed strains.

two or three bushels of seed per acre will often more than pay for the sacrifice of the hay. Michigan alfalfa growers should willingly pay more for this seed.

Higher yields of seed can be secured by planting at the rate of two to four pounds per acre in rows twenty-one inches apart, and cultivating during the first season. Without doubt, alfalfa production in Michigan would be on a much more stable footing were an ample supply of native, adapted seed produced within the State. In favorable seasons for seed production, old stands which have become thin, will seed fairly profusely and may be most profitably handled as a seed crop.

In ordering alfalfa seed for planting in Michigan, insist upon seed of American origin, or produced under conditions similar to, or more rigorous than, those existing in Michigan. Seed from Minnesota, the Dakotas, Montana and Idaho or native grown is best adapted. The State Seed Analyst, East Lansing, Michigan, will make a complete analysis of samples submitted at a charge of twenty-five cents per sample. Inspection is made free of charge.

SECURING INOCULATION.

Inoculation is necessary on soils where successful stands of alfalfa or sweet clover have not been grown previously. If plants of thrifty, well-established alfalfa are carefully dug up and the roots gently washed free of soil, small nodules will be found singly or in clusters on the roots. These nodules are the homes of countless nitrogen gathering bacteria, and through their aid the alfalfa plant is able to make use of atmospheric nitrogen. The bacteria found on alfalfa and sweet clover are similar and are interchangeable, but those found on clovers and other legumes are not suitable for inoculating alfalfa. On soil rich in nitrogen alfalfa may make a fairly successful growth without inoculation, feeding on soil

nitrogen, but for greatest success and in order to benefit the soil, thorough inoculation is necessary.

The most convenient way of insuring the presence of these bacteria in soils from which they are probably absent is the culture method. Small bottles of *pure culture for alfalfa inoculation can be secured from the Department of Bacteriology, Michigan Agricultural College at twenty-five cents per bottle.* One bottle is sufficient for a bushel of seed. In ordering, mention the date when you desire to make your seeding and fresh culture will be forwarded for that date. Directions for use accompany the bottle.

Another method, possibly more effective though not as convenient, is the soil inoculation method. Soil is taken from a field of thrifty, well-inoculated alfalfa or sweet clover from a layer just beneath the surface to a depth of four inches. It is best to shovel aside about one inch of surface and take for use a layer from one to four inches in depth. This soil should not be exposed to sunlight, and if somewhat wet, may be put in condition by spreading out to dry in a cellar, on a barn floor, or in a shaded room where sunlight will not injure the bacteria. When in condition, this should be spread broadcast or applied through fertilizer attachment or drill in the evening, or on a rainy or dark day, following immediately with harrow to cover the newly applied soil, unless a gentle rain should follow, or it may be applied at time of seeding through the fertilizer attachment. Applied through fertilizer attachment several hundred pounds per acre of inoculated soil is sufficient. To secure even distribution by broadcasting, a wagon load or more is needed.

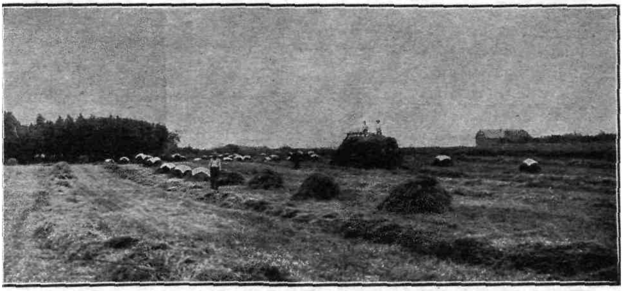
Once a field is successfully inoculated, it appears that inoculation will remain for many years provided soil conditions remain favorable. However, in view of the ease of inoculating it is advisable to make sure and to inoculate the seed or soil when planting on soil which has not grown alfalfa successfully, or not for a long period.

THE CARE OF ALFALFA MEADOWS.

During the first season, in the case of spring or early summer planted alfalfa, the growth of pigeon grass and weeds may be sufficient to warrant clipping. In this case the mower bar should be set high, six or eight inches, so as to clip as little of the alfalfa as possible, and the clippings allowed to lie on the ground. It is seldom that sufficient growth is made to warrant making a hay crop the first season. If a growth of a foot or more is secured it is advisable to clip in late summer with the mower bar set high allowing the clippings to lie on the ground. Clipping is also advisable when leaf spot, a fungous disease of alfalfa, causes the leaves to turn decidedly yellow and begin to drop. Pasturing should not be permitted during the first season. On areas of the field which are particularly exposed, or where winter-killing is likely due to poor drainage or lack of organic matter the application of light dressings of well rotted manure, three or four tons per acre, in late fall or early winter will aid in preventing heaving and winter killing. A heavy ap-

plication may do more harm than good. If sufficient manure is available such treatment of the entire field is advisable. Well-rotted or composted manure is best since not so likely to introduce grass or weed seeds. *Seedings made in late June or during July need no other attention than the light top dressing of areas likely to winter-kill.*

During the second season the first cutting for hay will be available during late May or early June. It is advisable to cut when small shoots begin to appear at the base of the stems. At this time alfalfa is usually from one-tenth to one-fifth in bloom. One of the most successful ways of curing alfalfa is to cut during the morning and allow to lie on the



Alfalfa hay cures best in small cocks. Even under favorable conditions, good hay may be made by opening and recocking after rains. Hay caps make curing even more dependable. In exceptionally fine weather, successful curing may be accomplished in windrows. The use of hay loading and stacking machinery is becoming general on large alfalfa farms.

ground until wilted in the swath. It should then be raked into windrows by the use of the side-delivery or sweep-rake. Usually it is ready to rake *late in the morning following.* On very hot, dry days when curing is rapid it may be raked up the afternoon or evening of the day on which it is cut. Under favorable conditions alfalfa may be cured in windrows, but it is safest to throw into cocks immediately so that the curing may take place under more certain conditions. Fairly green alfalfa, wilted sufficiently to allow raking, which is cocked immediately, usually cures into excellent hay even under adverse conditions. After a rain it takes *but an hour or so to open the cocks of an acre or more and to throw them* together after drying. *Alfalfa should never be allowed to dry in the swath to the extent that the leaves fall off easily.* The leaves furnish the most valuable part of the hay, and pound for pound are almost equal *in feeding value to bran.* By allowing to wilt in the swath and raking into windrows or throwing into cocks the leaves continue to transpire moisture and dry the stems. Though alfalfa may be handled with less loss by using the fork in all operations of curing and stacking, it is nevertheless usually more practical and economical on large alfalfa

farms to rake with the side-delivery rake, pick up with the self-loader, *and stack with fork or slings.*

The use of hay caps on the cocks during curing insures a better color and quality of hay, and will prevent loss during unfavorable conditions. Canvas caps, about three and one-half or four feet square with corners weighted with pieces of metal, or cement balls, or carrying stakes on strings which may be thrust into the cock, will effectually shed rain and insure proper curing.

Still productive after nine years of successful hay crops. Usually alfalfa fields should be plowed or pastured at from four to six years after seeding.

Two cuttings are usually secured during the second season, or if the year is very favorable, *three will be secured. The third and following* seasons, three cuttings are usually secured and occasionally in very favorable years four may result. Usually during the third and fourth season June grass will make its appearance. At that time it is advisable after removing the hay crop to *cultivate with spring-tooth or spike-tooth harrow in order to drag out the June grass.* The too drastic use of the spring-tooth may injure alfalfa, but if properly used the June grass with its surface root system will suffer much more injury than the alfalfa with its deeply anchored tap root. While alfalfa fields ten years or more in age, and still producing successfully are occasionally to be found in Michigan, it is usually advisable after the fourth or fifth year to turn under an alfalfa sod, and follow with cultivated crops, or these crops in an ordinary clover rotation, for a period of four or five years before reseeding to alfalfa. Alfalfa sods are often followed with cultivated crops for several years, reseeding to alfalfa alone or with barley or oats as a companion crop.

A newly turned alfalfa sod—hard breaking but a good foundation for a big corn crop.

ALFALFA IN ROTATION.

Alfalfa is not likely to supplant red clover and alsike, or clover and timothy mixtures, in Michigan rotations but will strongly reinforce these crops. As a general rule, alfalfa is seeded with the intention of allowing it to remain for from four to six years, or as long as it will produce hay successfully. Often only portions of Michigan farms are adapted to its profitable culture, and the expense of draining and liming is frequently considered too great to apply to more than a comparatively small area at one time. Owing to these facts, alfalfa should be considered a crop to grow in connection with the ordinary clover rotation, which usually occupies the greater area of the farm. After from four to six years alfalfa is usually sod-bound, and after a year of pasture is turned under to be followed by corn and other cultivated crops. The growing of alfalfa for a period of years puts land in excellent condition for crops of corn, beans, or potatoes, and after these crops alfalfa may be again seeded either alone or with small grain as a companion crop. It is possible to divide that portion of the farm suited to alfalfa into a proper number of fields for the alfalfa rotation, or the alfalfa may be followed by four or five years of crops grown in an ordinary clover rotation. Common weeds give little trouble after alfalfa is once established, owing to the frequent cuttings. Seeding land infested with Canada thistles, to alfalfa, is an excellent way to get rid of this pest. June grass and quack grass, however, are the great enemies of alfalfa, and unless land is fairly free of these grasses, will greatly shorten the period of profitable production of the alfalfa field.

Additional Michigan Experiment Station Publications of interest to alfalfa growers.—

Bul. No. 271—Alfalfa Growing in Michigan, 1913.

Popular Bul. No. 284—Phosphorus on Michigan Soils, 1919.

Exp. Sta. Bul. No. 91—Information on Lime and Its Use and Function in Soils, 1918.

As pasture for growing hogs, a good stand of alfalfa is unexcelled.
(Animal Husbandry Section, Michigan Experiment Station Pasture Experiments 1916.)

WHY GROW ALFALFA.

To get the largest yield of the best hay per acre.

To reduce feed bills.

To increase production of meat and milk.

To increase the humus and nitrogen content and to improve the condition of the soil.

To eradicate Canada thistles and other weeds.

HOW TO GROW ALFALFA.

Plant only on well-drained fields.

Prepare seed bed thoroughly.

Apply ground limestone, marl, beet factory lime, or hydrated lime.

Use acid phosphate or rock phosphate, and manure to increase yield.

Inoculate soil where alfalfa or sweet clover has not been grown successfully.

Plant hardy northern grown strains.

Cut for hay when shoots show at crown.

Wilt in swath and cure in windrows or cocks.

Harrow old stands after cutting to retard June grass.

WHERE TO GROW ALFALFA.

Where more leguminous hay is needed than clover will supply.

On any Michigan soils which are

Well drained;

Well supplied with lime;

Where June grass and quack grass are under control.

WHERE NOT TO GROW ALFALFA.

On poorly drained or seepy soils.

On acid soils or soils needing lime.

Where the cost of liming, draining and fertilizing is too great.

Where June grass and quack grass are unsubdued.

PLANTING THE RURAL SCHOOL GROUNDS

Circular No. 36

BY C. P. HALLIGAN

General Aim

Any plan for the improvement of the school grounds should first of all be simple. No elaborate or pretentious effects should be attempted in their development. The primary aim should be to retain and increase the natural beauty of the surrounding scenery, making the grounds a beauty spot in the rural landscape, rather than a formal, artificial, or imported element in the scenery. A school ground should possess the same general character of beauty as is indigenous to the neighborhood, making it appear not as something separate and distinct from the surroundings, but as an attractive and pleasing portion of the general landscape.

Use of Native Plants

For these reasons the trees, shrubs, and plants that are used to develop the rural school grounds can well be of the kinds found in the neighboring fields and woods. Such plants will be naturalistic and harmonious in the landscape, and better adapted to the climatic and soil conditions of the place than some exotic plants that might be purchased from a nursery.

Therefore, the expense that might be incurred in purchasing plants for the work should not detain ambitious teachers from developing the school grounds. Nursery plants of the kinds most adapted to the conditions are easier to transplant successfully because of their more branched and fibrous root systems, but similar kinds from the fields may be successfully transplanted if the work is carefully and properly done.

The interest and enthusiasm of children may be aroused for this work by arranging field excursions in the early spring,—which is the season when the plants should be transplanted,—to fields and woods, where they may be found, and where under the teachers' direction they may be carefully dug and then transferred to the school grounds. The earlier in the spring this work is done, the better are the chances of success. The aim in digging should be to retain as many of the roots as practicable and to keep them moist and protected from exposure to sun and wind. In so far as it is sometimes difficult to identify many of the plants in early spring when there is no foliage upon them, it is often desirable to have field excursions in the early fall while the leaves are still on the plants and to mark such plants as are desired for spring planting. Such an excursion could be made in connection with a lesson in botany or nature study work.

The Planting Plan

Before the planting is started a plan should be drawn to a definite scale (say of 1″ to 10′), showing the size and location of all existing buildings, walks, drives, plantings and boundaries of the property. With this data

as a basis a complete planting plan of the property may be made. The execution of the plan then may be gradual. The most important parts may be developed first and the others as circumstances permit. Such a plan will then serve as a definite record for future reference, and will tend to insure the progressive development of the scheme that otherwise might be forgotten.

Where to Plant

Trees should be planted about the boundaries of the property for shade and general protection against the winds; also in the rear of the buildings to produce a proper back ground. The trees may be arranged to enframe the building and to hide undesirable views either within or without the property.

Hardy shrubs are especially desirable in masses or groups about the boundaries of the lawn, and about the foundation of the school building; also in front of the out-buildings and other undesirable elements, as screens, and sometimes as a hedge to take the place of an undesirable fence.

Vines may be used to cover walls, fences, out-buildings, banks or may be trained about the entrance of the porch. With wooden buildings they should not be used to cover the sides of the structure as they are very apt to induce the wood to decay.

Rules for Planting

The following general rules should be observed in planting:

1. Preserve as many of the fibrous roots as possible.
2. Expose the roots as little as possible to the drying influences of the sun and wind.
3. Prepare the roots for planting by cutting away the bruised and broken portions.
4. Plant an inch or two deeper than the plant stood in the field. If the soil is very sandy, the plants may be set two to four inches deeper.
5. Dig the hole in which the plant is to be set deep enough to receive two or three inches of fine top soil before putting the plant in place, and make it wide enough to allow the roots to spread in their natural position without crowding.
6. See that good friable surface soil is firmly packed beneath and over the roots.

Native Plants Available

A suggestive list is here given of the more common native plants, that may be available in neighboring fields, for improving the rural school grounds:

NATIVE TREES

Sandy Soil	*Medium to Heavy Soils*	
Jack Pine	Sugar Maple	Elm
White Pine	White Spruce	Red Maple
Carolina Poplar	White Oak	Linden
Red Oak	Beech	Alder
Sassafras	White Cedar	Hemlock

Large-toothed Aspen
White Birch
Red Cedar
Hawthorn
Sycamore
Hop-tree
Tulip tree
Iron-wood
American Ash
Black Walnut
Sheepberry
Swamp Oak
Peach-leaved Willow
Black Willow
Flowering Dogwood

NATIVE SHRUBS AND HERBACEOUS PLANTS

Prairie Rose (Rosa Setigera)
Staghorn Sumac
Dwarf Sumac
Sand Plum
Prairie Willow
Bush Honeysuckle
Common Juniper
Trailing Juniper
Sweet Fern
Common Braken Fern
New Jersey Tea
Wild Rose (Rosa Humilis)
Red Elder (Shade)
Wild Rose (Rosa Carolina)
Black-berried Elder
Hazel
Button Bush
Red Dogwood
Winter Berry or Black Alder
Shad Bush
Spice Bush
Willows (Several native varieties)
Flowering Raspberry
Black Haw
Arrow-wood
Hardhack
Meadow Sweet
Bladdernut
Snowberry
Indian Currant
Sweet Gale
Christmas-fern (Shade)
Ostrich-fern (Shade)

NATIVE VINES

Bitter Sweet
Honeysuckle
Wild Grape
Virginia Creeper
Moonseed

RASPBERRY CULTURE

Circular No. 37

BY R. E. LOREE

The raspberry is well adapted to cultivation in Michigan and in some sections of the state ranks high among the small fruits as a commercial crop. Conditions are ideal in many localities for raspberry growing and they should be more commonly grown both as a market and as a home garden product. In many towns and cities of the state the demand for raspberries in a fresh state far exceeds the supply. Such markets furnish excellent opportunities for those who are fortunate enough to have a nearby location and sufficient labor to harvest and care for the crop. More raspberry plantings should be made in farm and suburban gardens and there are many city gardeners who could well afford to devote some space to their cultivation. Their culture is comparatively easy and with ordinary care and attention small plantings often supply an abundance of fresh fruit for the table in season and some surplus for canning and preserving for winter use. Profitable crops may be expected the second or third year from the time of planting, and the plantation should remain in a profitable condition for several years depending upon the care which it receives.

While success in raspberry growing depends very largely upon the individual care and attention of the grower, much depends upon the soil and location of the plantation. Nearness to market or shipping point is an important factor in commercial growing. The fruit is soft and must be marketed quickly and with little handling. Considerable labor is also necessary for harvesting the crop. The most profitable plantations are those which are located near the larger towns and cities where the product can be marketed quickly and economically, and where pickers can be easily secured.

SOIL AND LOCATION

Raspberries may be grown on almost any well drained soil. A sandy loam or clay loam is best. An abundant moisture supply is most important. The surface soil must be deep and well supplied with humus and should be underlaid with a porous yet retentive subsoil which will keep the water table near the surface. Shallow soils especially if lacking in humus often dry out quickly. They should be made deeper and improved by the use of cover crops and stable manure. Raspberries do not thrive on wet soils or those which do not allow excess moisture to drain off quickly. They require large amounts of moisture, especially during the fruiting season, yet easily suffer from any excess of moisture in the soil. The soil should always be moist and very retentive to secure the best results but should never be wet.

Whenever possible a slightly sloping site somewhat higher than surrounding lands should be chosen. Low lands or valleys which have no natural outlet for the heavy cold air which settles in from higher levels

should be avoided. Raspberries grown on such lands are more subject to injury from late spring frosts and the canes are more often killed by severe winter freezing than those grown on higher and more favorable situations. Hill tops or steep slopes are undesirable as much fertility may be lost and the plants injured by excessive washing of the soil. Northern exposures are often preferred, though not necessary. They are cooler and less subject to drouth and larger and finer berries are secured.

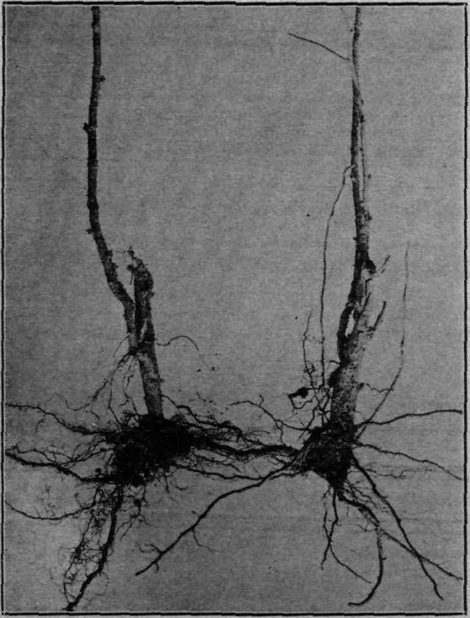


Fig. 2.—The red raspberry is propagated from suckers which arise from underground stems.

PLANTS AND PLANTING

Propagation. New plants may be purchased from a reliable nurseryman or they may be secured from established plantations.

The red raspberry is commonly propagated from the suckers or shoots which spring from underground stems. These may be dug up and used for new plants. The best plants to use are the young shoots which come up

in the fall after cultivation or early in the spring. They should not be pulled from the soil but carefully lifted with a spade, otherwise the young shoots will be broken from the underground stem with but few small roots attached.

The black raspberry is propagated from rooted tips. During late August the long canes bend to the ground where, if undisturbed, they become rooted and produce new plants. The tips are often covered with soil during cultivation and take root, but if a considerable number of plants is desired it may be necessary to bury the tips with a hoe or spade to insure contact with moist soil until good roots are produced. The rooted tips may be dug in late fall, or better still, left in the ground until the next spring. They are removed by cutting off the parent cane a short distance above the new plant and carefully lifting to avoid unnecessary breaking of roots. Better plants may be secured from young plantations. They are usually more vigorous and free from disease than those taken from older plantations.*

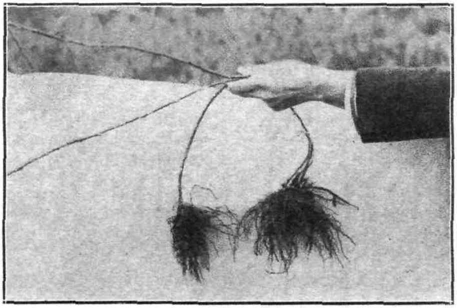


Fig. 3.—The black raspberry is propagated from rooted tips.

Preparation of the Soil. Plants should not be set on newly broken sod land. The soil should be well fertilized and cultivated and all weeds and grass thoroughly subdued. It is advisable to grow a hoed, or cultivated crop on the land the year previous to planting. The soil should be plowed deeply and harrowed until it is in a fine mellow condition for planting the same as for any other crop. Young plants set in well prepared soil become established more quickly and less work will be necessary in caring for them during the first and succeeding seasons.

Time of Planting. The best time for planting raspberries is in early spring. It is usually safer, and better plants of the black raspberry can be secured. Red raspberries may be planted in the fall on the lighter types of soil but if done some form of mulch should be provided for protection and to prevent heaving from the soil by frosts.

*See plant diseases on page 611.

Distance of Planting. Raspberries may be grown in hills and the cultivator used on all sides of the plants, or they may be grown in more or less solid or continuous rows and the plantation cultivated in only one direction.

When grown in hills a distance of five feet apart each way is satisfactory, though they are sometimes planted closer. The hill system has the advantages that less hand work is necessary to keep suckers and weeds under control; more sunshine and air reaches all parts of the plant; the *fruit is more easily picked; and larger and finer berries are secured.*

Both the black and red raspberries are commonly grown under the row system. The plants should be set three feet apart with a space of six to eight feet between the rows. Unless space is limited or land values high, the latter distance is recommended. The plantation should be cultivated in both directions the first season or sometimes longer until the plants begin to fill in the spaces, after which the cultivator is run in only one direction.

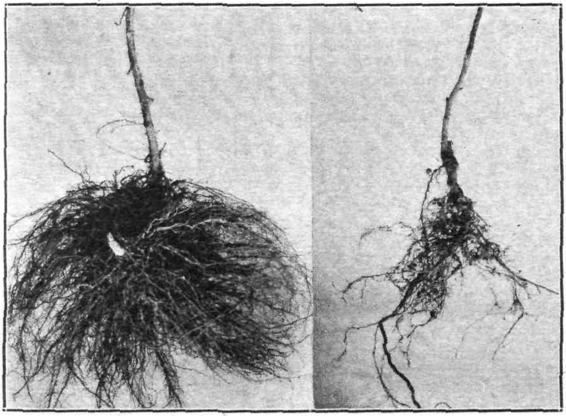


Fig. 4.—Well rooted raspberry plants ready for setting. Black raspberry at the left, red raspberry at the right.

Setting the Plants. The canes of the new plants should be cut back to about six inches in length at the time of planting. They should be set some deeper than they originally were in the soil. Red raspberry plants may be set as much as three or four inches deeper, but care must be taken not to cover plants of the black varieties too deeply or the tips may be smothered. They should be set so that the tips are not covered with more than two inches of soil. It is best to set the plants in the bottom of a furrow about four inches deep and cover them at first to a depth of one or two inches, later filling in the furrow by cultivation as the new shoots

develop. This leaves the crown of the plant well below the surface of the soil, so that they suffer less from drouth and the canes are less liable to be blown over than when they are planted shallow. The plants should be set in such a manner that the tip or bud in the center of the mass of roots is in an upright position regardless of the position of the piece of old cane which is attached. Handle the plants carefully. The tips are tender and easily broken. Do not expose the plants unnecessarily to the wind and sun. Be sure that the soil is well firmed about the roots and finally cover with a little loose soil to prevent evaporation.

CULTIVATION

Thorough and clean cultivation is essential. Grass and weeds must be kept out of the rows and the surplus suckers of the red raspberry destroyed. The soil should be plowed shallow and prepared early in the spring and kept in a loose friable condition during the season by frequent stirring. Use the cultivator or harrow as soon as possible after each rain and at least once each week during dry seasons to conserve moisture. Deep tillage should not be practiced as many roots are thus injured and suckers of the red raspberry become more numerous and difficult to control. Cultivate just deep enough to break the crust and keep a loose mulch on the surface at all times. Some cultivate deeply at first to force the lateral roots to form at a considerable distance below the surface. Shallow cultivation later prevents excessive sprouting because the deep laying permanent roots are uninjured. Usually cultivation is discontinued with the beginning of the picking season but it is often beneficial, especially in dry time, to loosen the soil between the rows after each picking. This is permissible, if it can be done without knocking off the fruit or injuring the plants. One or two cultivations after the fruit is harvested may be necessary to clean up the patch and loosen the soil after which a cover crop should be sown to be turned under the next spring. Late fall cultivation tends to induce a new growth which may not fully mature and may therefore be more easily injured by winter.

Mulching each year with several inches of straw, leaves, or marsh hay may be substituted for cultivation and is often profitable, but on account of the high cost and difficulty of securing suitable mulching material the operation is not often practiced except in the small patch. It is of special value in the home garden. Moisture is often conserved as well as by cultivation; the soil is constantly improved and better crops of berries often secured.

FERTILIZERS

Well rotted stable manure is the best fertilizer for raspberries. Stable manure not only adds plant food to the soil, but furnishes large amounts of humus which improves the texture and physical condition of the soil and increases its water holding capacity.

The amount to apply depends upon the type and previous preparation of the soil. On good soils which have been well prepared an annual application of about ten tons per acre is recommended. On the lighter types of soils, heavier applications of fifteen to twenty tons per acre may be necessary.

When stable manure can not be easily obtained, cover crops may be used to keep up the humus supply. Oats sown at the time of the last cultivation, or about the middle of August, at the rate of two bushels per acre will provide a good supply of organic matter to turn under the next spring. *Clovers, vetch, or rye may be used providing they are drilled in* between the rows and turned under very early in the spring. Otherwise they may become established among the plants and considerable hand labor may be necessary to eradicate them.

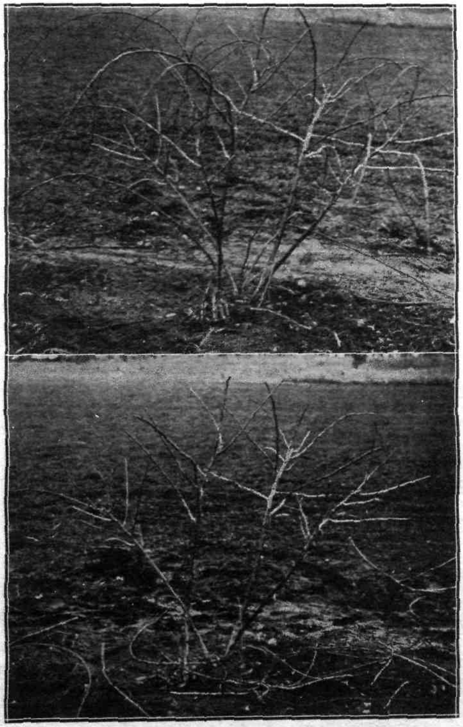


Fig. 5.—Black raspberry plant before and after pruning in the spring.

Commercial fertilizers may be used to supply the mineral elements to the soil. They should contain relatively high percentages of phosphoric acid and potash with nitrogen in a slowly available form. Large amounts of quickly available nitrogen either in the form of commercial fertilizer or stable manure often induces an excessive cane and leaf growth and lessens fruit production.

When no stable manure is applied and cover crops used to supply humus, an annual application in the spring of equal parts of ground bone, acid phosphate, and muriate of potash, applied at the rate of 500 pounds per acre, is recommended. If desired to supplement light applications of stable manure, an application consisting of 200 pounds of bone meal or acid phosphate and 100 pounds of muriate of potash may be used.

PRUNING AND TRAINING

The fruit of the raspberry is borne on lateral or side shoots from canes of one season's growth. The canes usually bear but once, that is, the canes are produced one year, bear fruit the next, then die. The objects of pruning, therefore, should be to remove all old canes which are of no use in the plantation, and to provide a proper number of new canes for the produc-

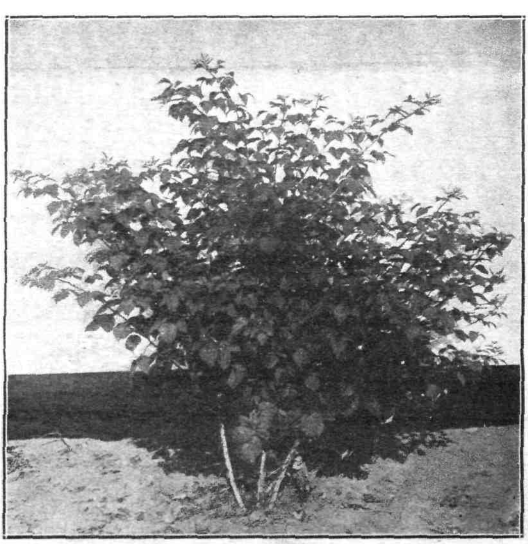


Fig. 6.—A well grown black raspberry plant. Only 3 to 5 of the best canes are left for fruiting.

tion of fruit the following season. Some growers do not remove the old canes until winter or until the pruning is done early in the spring. It is best to cut them out immediately after all the fruit is picked. They should be removed from the patch and burned. Insects and diseases are in this way better controlled and the new canes are provided with better conditions for development.

Black Raspberry. During the summer the new growth of the black raspberry is pruned by pinching out the tips of the young growing canes when they are about 18 to 24 inches high. This checks the terminal growth and induces the development of low, stocky, well-branched plants which will stand erect and need no support. Be sure to pinch back the canes as soon as they have reached the desired height. In order to do this it is usually necessary to go over the patch several times during the growing season as all the canes do not appear at the same time. Weaker plants result if the canes are allowed to grow beyond the desired height and cut back later. In the spring the canes should be thinned out leaving only 3 to 5 strong canes to each plant, and all lateral or side shoots cut back to 12 to 18 inches in length.

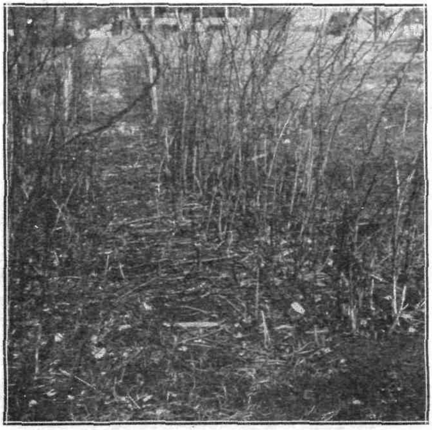


Fig. 7.—Cuthbert red raspberry. Rows too wide and canes not properly thinned.

Red Raspberry. The pruning of the red raspberry consists of removing all old canes at the close of the picking season and thinning out the new growth. The new canes are not tipped back, but allowed to grow as they will. Proper thinning and spacing of the new canes is important. Most varieties produce suckers very freely from the underground stems and if all are allowed to grow, the plants become crowded and the ground soon

becomes covered with sucker plants. All suckers and weak canes should be cut out and if they are kept in hills not more than 5 to 7 of the best canes should be left in each hill to produce the next season's crop. They are most commonly allowed to fill in the spaces between the original plants forming a solid row or hedge. The hedge-rows should not be allowed to become more than 10 or 12 inches wide and the canes should be well spaced so they will stand at least 6 or 8 inches apart. All suckers which appear outside the limits of the row or hill should be treated as weeds and destroyed by cultivation, or if necessary, chopped off with the hoe. No pruning back is necessary in the spring unless the canes are

Fig. 8.—Cuthbert red raspberry. The canes are well spaced in the row.

very tall or weak and no support is provided for them. They are then cut back to a height of 4 to 5 feet so that they will support a crop of fruit.

Both the black and red raspberry are pruned and trained so that under ordinary conditions no wires or trellising are necessary. There are some advantages if the canes are provided with some artificial means of support and it usually pays. The canes are kept up out of the way making cultivation easier, the fruit is more easily picked and there is less loss of fruit from becoming covered with soil or splashed with dirt by rains. When red raspberries are grown in hills a strong stake should be set in the center of each hill and the year old canes tied to it. When grown in rows the bear-

ing canes may be kept erect by tying them to a single wire which is stretched about four feet high on posts set about 20 or 30 feet apart in the rows; or two wires, one at three feet and one at five feet, may be used in making this kind of a trellis, and the canes tied to both the upper and lower wires. A very simple and satisfactory form of trellis may be made by nailing cross pieces about fifteen inches in length to posts. Wires are stretched from the ends of the cross pieces, one wire on each side. The plants grow up between the wires and are supported by them. When the black raspberries are properly summer pruned, the canes become very sturdy and self-supporting and a trellis is considered unnecessary. It is

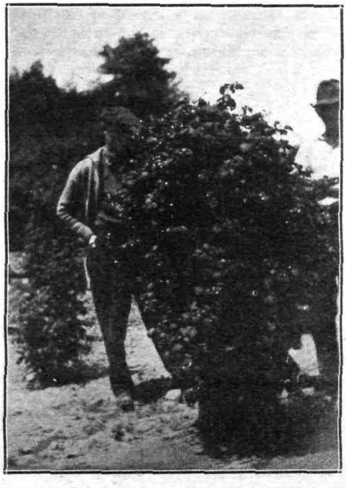


Fig. 9.—Cuthbert red raspberry grown in accordance with the hill system.

sometimes an advantage to place a stake near each plant and tie the canes to it, or if desired the two wire trellis just described will be found very satisfactory.

HARVESTING

The raspberries should be handled carefully to avoid bruising. The bushes should be picked over often. During the height of the season, picking at least every other day is necessary. The berries should be firm but not over ripe to reach the market in good condition. In the home garden the fruit may be left on the bushes until quite ripe and a much higher flavor and quality will develop. Never pick when wet unless for imme-

diate use. Keep the fruit shaded in the patch and remove to a cool place or market them as soon as possible. The berries should be picked directly into the boxes in which they are to be sold and packed without further handling into crates. Both the black and red varieties are commonly sold on local markets in quart boxes. Pint boxes are often preferred for the reds and should be used if they are shipped to a distant market.

DURATION OF PLANTATION

The number of crops which may be taken from the plantation is determined very largely by the care given it by the grower and the prevalence of insects and diseases. The average life of black raspberry plantations is about 5 to 7 years and that of the red raspberry 8 to 10 years. They may be kept in bearing longer but it is often not profitable to do so. Whenever diseases and insects become very troublesome and weeds and grass difficult to control, the plantation should be destroyed and new plantings depended on for future crops.

INJURIOUS INSECTS

Approved by the Department of Entomology.

Tree-cricket. The presence of this insect is known by the rows of egg punctures. These are often so close together that they make an almost continuous slit two or three inches long, running lengthwise of the cane. The rows of punctures tend to either kill the upper part of the cane or weaken it so as to prevent the proper development of the fruit. This

Fig. 10.—Black raspberries in the home garden. Bearing canes tied to stakes.

insect may be controlled by collecting the canes containing the eggs and burning them.

Raspberry Cane-borer. During June and July these insects appear and work on the new growth a few inches from the end of the canes. The female insect makes two rows of punctures around the cane about one-half inch apart between which the egg is laid. The girdling causes the tip to wilt. The egg hatches and the larva bores down through the pith, usually causing the death of the cane. As soon as the tips in which the eggs are deposited are noticed they should be cut off below the girdle or tunnel and destroyed. Prompt removal of the canes at the end of the fruiting season will also aid in keeping this insect under control.

Raspberry Sawfly. A small thick bodied fly which appears in May. The female deposits her eggs between the two layers of the leaf. The young larvae begin to feed as soon as hatched and at first eat out irregular holes and finally the whole leaf. The green larvae may be brushed from the bushes during the heat of the day and will often die before they can get back to the food plant. Spraying with hellebore used at the rate of one ounce to one gallon of water is very effective.

DISEASES

Approved by the Department of Botany.

Crown Gall. This is a bacterial disease which occurs on many fruits and is often especially injurious to raspberries. It is easily recognized by the galls or knotty growths which appear at the surface of the soil, or at some distance above the ground on the canes. When making new plantings do not set infected nursery stock or take plants from fields where it is known to exist. Remove old plants which are infected and burn.

Anthracnose. A serious and common disease of the raspberry, distinguished by grayish white spots with a purple-colored margin which appear most commonly near the base of the canes. Control: Take out diseased canes at the end of the fruiting season. Practice clean cultivation. May be controlled by spraying with lime-sulphur or Bordeaux mixture. Recent experiments show that it can be most satisfactorily controlled with lime-sulphur. Three applications should be made. First, in the spring before the leaves appear; second, when the new shoots are about six inches high; third, just before the blossoms appear. For the first application the lime-sulphur is diluted at the rate of 2½ gallons in 50 and for the later applications at the rate of 1¼ gallons in 50. For further particulars see Michigan Special Bulletin No. 88.

Yellows or Curl. One of the most serious diseases of the red raspberry in Michigan. Cause not known. The plants are stunted, sickly, and bushy in appearance. Both healthy and diseased plants may occur in the same clump. The leaves are curled and become mottled in appearance. The berries on diseased plants usually become dry before ripening or they may ripen from ten days to two weeks early. Cannot be controlled by spraying. Dig out and burn diseased plants.

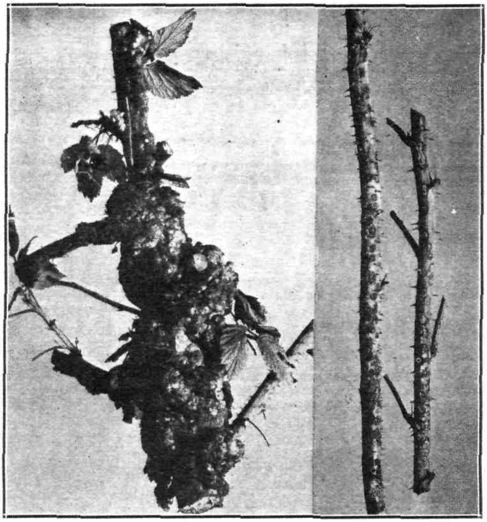


Fig. 11.—Two common diseases of the raspberry. *Crown Gall* at the left, ***Anthracnose*** at the right.

Cane-blight. The chief damage is done to the fruiting canes. Causes a wilting of the cane and foliage and the berries dry up. Sometimes called raspberry cane-wilt. Often only a single branch or a small portion of the cane is blighted. In other cases the whole cane may be affected. No definite means of control can be given. Remove and burn dead and diseased canes after the fruiting season and again in early spring.

Orange-Rust. May be known by the red rust that appears on the leaves and sometimes on the canes. Orange-red spots appear on the under side of the leaves and they become dwarfed and rolled and finally drop from the plant. The plants are stunted but not killed. Dig out diseased plants and destroy them as soon as they appear. All wild raspberries and blackberries in the vicinity known to be affected should be destroyed.

VARIETIES OF RED RASPBERRIES

Cuthbert. The best known and most valuable variety. Grown more than all other varieties combined. The bushes are tall, upright, hardy and vigorous, and produce fine crops of large conical, bright red berries of

excellent flavor and quality. Highly recommended for commercial and home planting.

King. Regarded by some as a valuable variety because of its earliness. The bushes are hardy though not as large when grown under the same conditions as those of the Cuthbert. The canes are stiff and upright and very strong growers. The fruit is large, firm, bright red, but must be harvested before very mature or it will drop badly. A valuable early sort worthy of trial.

Herbert. Of Canadian origin. Not grown to any extent in the state but worthy of trial. Berries large, conical, bright red, not as firm as the Cuthbert. Ripens a little earlier. Bushes hardy, vigorous, spreading and often very productive.

Miller's Red. One of the older standard early varieties. Considered by some as the best early variety, but it is not satisfactory as grown here. It begins to ripen a little earlier than the King but in other respects is excelled by that variety.

St. Regis (Everbearing). Berries small to medium, deep red, only fair in flavor and quality. Bushes hardy, upright and vigorous. Bears a fair crop during the usual season and continues bearing until late fall. Not enough fruit is secured at any one picking to be sufficient for marketing except from comparatively large plantings. May be planted in the home patch to extend the raspberry season but is not recommended for general planting in the state.

VARIETIES OF BLACK RASPBERRIES

Cumberland. This variety occupies the same place among the black varieties as the Cuthbert does among the reds. It is the standard black raspberry. The plants are tall, upright, vigorous and hardy and very productive. The berries are large, firm and very good in quality and appearance. A good shipper. The best mid-season variety for commercial or home use.

Plum Farmer. A new variety which is becoming very popular with some growers. The plants are very vigorous, somewhat spreading, and very healthy. Thought by some to be less susceptible to anthracnose than the Cumberland. The fruit is very attractive, firm, a good shipper and of excellent quality. A promising early variety for home or commercial plantation.

Gregg. One of the best late varieties. Very vigorous and productive and spreading in habit of growth. The berry is large and firm and is covered with a whitish bloom. A valuable late market variety.

Hoosier. One of the newer varieties which is worthy of trial. The fruit is medium to large in size and of good quality. The plants are tall, vigorous and productive. Hardy. About the same season as Plum Farmer.

Kansas. A very good early variety. The plants are hardy but not as vigorous and productive as the other varieties named. Has been quite extensively planted but is now being replaced by other more promising sorts.

Eureka. Highly recommended by some as a valuable early variety. Has not proved satisfactory under test. The berry is small and often crumbly and only fair in quality. The plants are lacking in vigor and productiveness as grown on the Station grounds.

PURPLE RASPBERRIES

The purple raspberries are hybrids of the black and red varieties. Their habit of growth and method of propagation and culture is very similar to that of the black raspberry. They are very hardy, vigorous and productive and the berries are very good for canning. The most common varieties listed are the Columbian, Haymaker, Cardinal, and Shafer. The Columbian is a very fine variety of this class and is highly recommended.

YELLOW RASPBERRIES

The yellow raspberries are very similar to the red varieties except in the color of the berry which is a deep yellow. Their culture and method of propagation is the same as described for the red raspberry. The Golden Queen is the most common variety. It resembles the Cuthbert in shape and size of berry and habit of growth.

CURRANTS AND GOOSEBERRIES

Circular No. 38

BY R. E. LOREE

The currants and gooseberries are not grown as extensively in Michigan as the other small fruits, yet they occupy an important place in the fruit industry of the state. Michigan is one of the leading states in the production of these fruits. The climatic conditions are very favorable for them and as they are very hardy, they may be successfully grown in most sections of the state. They are easily grown and this combined with their hardiness and desirability for culinary purposes recommends them for planting in the small fruit garden as well as the commercial plantation.

LOCATION AND SOIL

The climatic and soil requirements of the currants and gooseberries are very similar. Both are by nature northern plants and in their wild state are always found growing in cool moist places. They do not thrive in hot dry situations. For this reason the cool northern exposures are desirable and should be selected whenever possible. Partial shade is an advantage and that of an orchard is desirable, but it is not advisable to plant currants or gooseberries in an orchard unless the soil is very fertile and the bushes are set so that they will not interfere with the care and growth of the trees. In the home garden the north side of a building or fence is a good location.

Both the currants and gooseberries will grow and produce some fruit on almost any soil. They prefer a naturally cool, moist, fairly heavy soil. A deep, moderately fertile, well-drained clay loam which is well supplied with humus is best. They also succeed well on strong, moist, sandy loams. Light sandy loams should be avoided as far as possible. Such soils, if used, should be well built up with stable manure and leguminous crops before and after planting. Clay soils are often satisfactory if properly handled, but they are difficult to work and require heavy annual applications of well rotted stable manure to keep them in a loose, friable condition.

PROPAGATION

The plants may be secured from any reliable nursery or they may be propagated and grown at home. In most cases it is better to purchase the needed plants from those who make a specialty of growing them. Much time is saved and frequently it is cheaper in the end to buy good strong well-rooted plants of a recommended variety than to attempt to grow them in a small way.

Currants are easily propagated from hardwood cuttings, about six or eight inches in length, which are taken from well ripened shoots of one season's growth. They may be taken and planted either in the

fall or early spring. It is best to take them in the fall and store them over winter in damp sand, sawdust or moss in a cool cellar, or they may be tied in bundles and buried upside down so that the butts are covered with about three inches of soil in a well drained place out-of-doors.

They are planted in nursery rows early in the spring, setting them about four to six inches apart in the rows and deep enough so that only one or two buds are above the surface of the soil. The cuttings root quickly and the new plants which result are grown in the nursery rows for one or two seasons before they are used for planting. A few plants for home use may be propagated from layers. The stems are bent down and covered with soil leaving only the tips exposed. This is best done in early spring. A good root system will have developed on the buried portion by fall. It may then be detached from the old plant and set out in a permanent location.

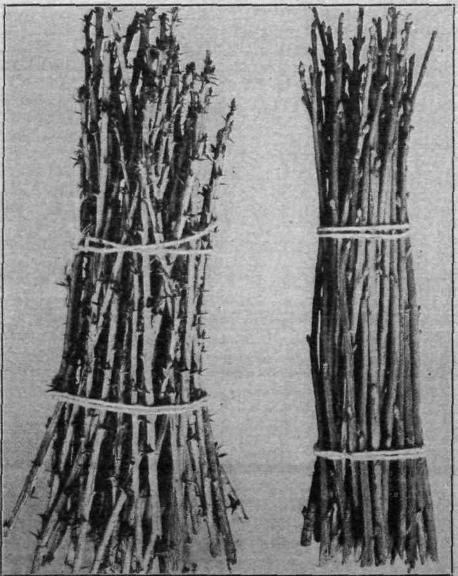


Fig. 2.—Cuttings of Currants and Gooseberries prepared for winter storage.

Gooseberries are propagated from cuttings and by layering. The method of propagation from cuttings is the same as described for the currant. Many varieties do not root readily from cuttings, and they are commonly propagated by mound layering. When this is practiced, the bushes are cut back severely in the fall. This induces the growth of a large number of strong vigorous young shoots the following season. About the middle of July, when the shoots have nearly completed their growth, soil is heaped up around and through the bushes leaving only the tips of the shoots exposed above the mound. Each shoot becomes rooted and may then be handled as a separate plant. Shoots of the American varieties produce good roots the same season and the separate plants may be removed from the mound and transplanted in the fall or they may be left until the following spring. Those of the English varieties require a longer time to produce a satisfactory root system and are left in the mound two seasons before separating. The rooted shoots are removed from the mounds and planted immediately or more commonly they are transplanted to nursery rows and grown for one or two seasons before they are used.

PLANTING

Soil Preparation. Thorough preparation of the soil is important. The land should be well manured and plowed deeply and the soil prepared by disking and harrowing until it is in a fine mellow condition to receive the plants. Well rotted stable manure applied in the fall or early spring and thoroughly worked into the soil in its first preparation helps to put it in a good water-holding condition and insures a quick, vigorous growth of the plants the first season. In places where manure cannot be obtained the soil should be built up by plowing under clover or other leguminous crops. Sod lands should be broken up and planted to some cultivated crop at least a year before the plants are set. Quack grass and other troublesome weeds must be destroyed for there is nothing which will run out a plantation of currants or gooseberries quicker than to allow quack grass to get in.

Distance of Planting. The distance of planting currants and gooseberries depends upon the fertility of the soil and the habit and vigor of the variety grown. They are commonly planted four feet apart in rows six feet apart. This allows for cultivation in one direction and occasional cross cultivation when necessary to clean out the rows. If it is desired to cultivate both ways a distance of five feet apart each way is satisfactory for the smaller growing varieties, while six by five, or six by six feet will be found a better distance for those of a more spreading and vigorous habit. Black currants are strong growers and should be given a little more space then the reds.

Time of Planting. The best time to plant currants or gooseberries is in the fall, though they may be planted with satisfactory results in the spring if the work is done early. The plants may be set any time after the leaves drop or the wood ripens in the fall, and if they are set fairly early, there is time for the plants to become well established before freezing weather sets in. They are then ready to commence growth as soon as the first favorable conditions are present in the spring. The chief objection to spring planting is that it is liable to be delayed until

after the buds start to grow and the first season's growth may be seriously checked. Plants which are set in the fall or very early in the spring always make a much larger growth the first season than those which are set after the buds have expanded into leaves.

Choice of Plants. Either one or two-year-old plants may be set. Good strong, well-rooted one-year-old plants are cheaper and have some advantages in setting over the two-year-old plants. The younger plants are more easily set; they suffer less from transplanting, and they are more certain to make a strong vigorous plant than if left crowded too long in the nursery row.

Setting the Plants. If a considerable number of plants are to be set the land should be thoroughly prepared, marked both ways, and a furrow run in one direction. The plants are then set at the intersection of the furrow and mark.

Prune all badly injured roots, and set the plants at least one or two inches deeper than they stood in the nursery row. Pack the soil firmly to bring it in close contact with the roots and leave a layer of loose soil on the surface to act as a mulch and prevent the packed soil beneath from drying out. When a few plants are to be set in the home garden it is best to dig the holes large enough so that the roots of the plants can be well spread out and deep enough so that some of the rich top soil may be placed beneath and around the roots.

CULTIVATION

Thorough and frequent cultivation is necessary to conserve moisture and keep the soil cool. Tillage should begin early in the spring by shallow plowing or discing and the surface soil kept in a fine, loose condition by frequent stirring with light fine-toothed implements during the summer. While the plants are young cultivation between the rows may be fairly deep but later cultivation should be shallow to avoid injury to the feeding roots which are produced in abundance near the surface. Cultivation should be discontinued soon after the fruit is picked and a cover crop sown. Oats or barley sown at the rate of two bushels per acre make the best cover crop for this purpose.

In the home garden where cultivation is inconvenient the plants may be mulched with coarse strawy manure, lawn rakings, or similar material. This will help to conserve moisture and keep the soil cool. The currants and gooseberries succeed well when heavily mulched and for this reason they may be planted in out of the way places in the garden where cultivation cannot be given.

FERTILIZING

Currants and gooseberries require large amounts of plant food and as the feeding roots are shallow and do not extend far it must be readily available and close at hand. Thorough cultivation and manuring are important. Stable manure is the best fertilizer and it is difficult to apply too much in growing these fruits. Young plantations need not be fertilized heavily, but after the plants begin to bear fruit heavy annual dressings of well-rotted manure should be applied, preferably in the fall or winter, to keep them in a good productive condition.

Commercial fertilizers may be used to supplement stable manures. Muriate or sulphate of potash applied at the rate of 100 or 200 pounds per acre sometimes increases the production and quality of the fruit. If necessary to depend upon commercial fertilizers as a source of plant food one containing 3% available nitrogen, 10% available phosphoric acid and 4% available potash, applied at the rate of 500 to 1000 pounds per acre, is recommended. However, in using commercial fertilizers it should be remembered that they add only the mineral elements to the soil, and it is therefore necessary to employ the use of stable manure, or cover crops, each year to maintain a good supply of humus which is highly important in growing these fruits.

PRUNING

Proper and systematic pruning is important. When the plants are set the tops should be cut back slightly and the bush balanced up as much as possible. Some pruning is usually necessary at the close of the first season after planting to shape the bush and regulate the number of main stems to be left.

About six stems should be selected and all others cut out. Those left should be headed back so that they are all of a uniform length. No further pruning will be necessary, except to keep the plants thinned out to a desired form and any straggling branches headed in, until the close of the fourth season. Some of the old wood should then be removed. In pruning bearing plants it should be kept in mind that the best fruit is borne at the base of the one-year-old shoots and on spurs which develop from two and three-year-old canes. Pruning, therefore, should consist in cutting out all the oldest canes each year and thinning out the new shoots leaving only a few of the strongest ones to replace the older bearing canes. A good bush should have from five to eight bearing canes, the number depending on the fertility of the soil and the vigor of the variety. It should be the aim in all subsequent pruning to provide this number of canes two and three years of age, and a good supply of young ones coming in to take their places. Very vigorous young shoots are sometimes headed in to induce the development of spurs along all parts of the stem. All branches tending to lie on the ground should be removed and the center of the bushes kept somewhat open by removing all crowding and interfering branches. Do not leave the bushes too thick. This is a common mistake in pruning these fruits. Larger berries and better filled bunches are secured and the fruit is more easily harvested if the bushes are not allowed to become too dense.

Black currents bear the most fruit on the one-year-old canes. Therefore, in pruning them the aim should be to keep up a good supply of young shoots. The wood must practically be renewed each year.

Pruning may be done any time during the dormant season, but it is perhaps better to do the work during late winter or very early in the spring before growth starts.

In pruning it is important to watch for any indications of the cane borer. A cane with a black center and somewhat hollow indicates the work of the borer and such a cane should be cut back until sound, healthy pith is reached.

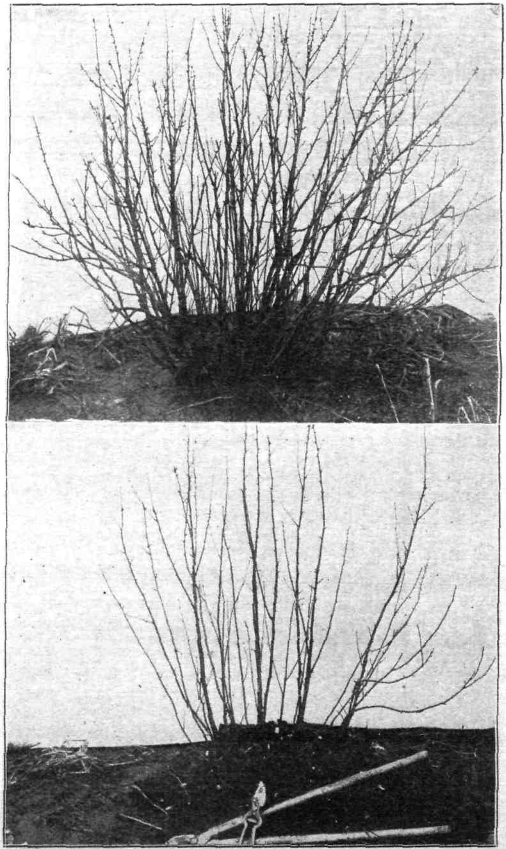
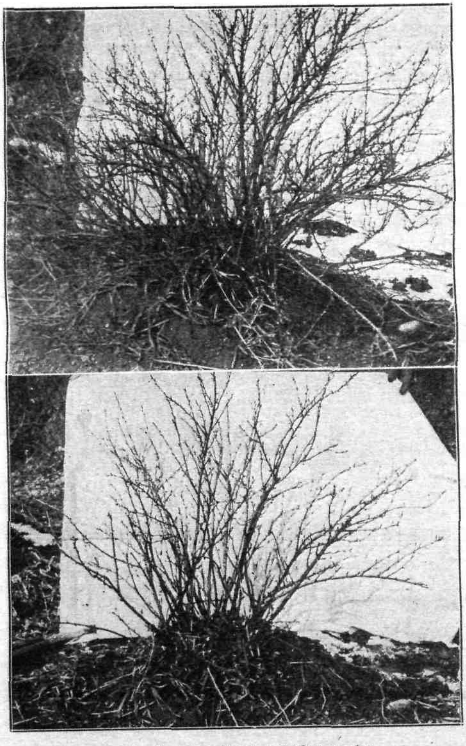


Fig. 3.—Currant before and after pruning.



Gig. 4.—Gooseberry before and after pruning.

HARVESTING

Currants which are harvested for market purposes should be picked and handled with care. The berries should not be stripped from the stem but taken from the bush with the clusters intact. The fruit should be dry when picked and not over-ripe. For nearby markets or for home use, they may be left on the bushes until nearly ripe but for shipments to a distant market the fruit should be picked while still very firm though well colored. The fruit is picked greener for jelly than for canning, a few green berries showing on each cluster.

Gooseberries are practically always marketed in the green state. The thorny nature of the bushes makes picking rather difficult, but if the branch is lifted with one hand and the fruit picked with the other there is little trouble as the fruit is found mostly on the lower side of the branch. On a commercial scale the fruit is usually stripped from the bushes,—the pickers wearing heavy gloves,—and run through a fanning mill to remove the leaves.

Currants and gooseberries are commonly marketed in quart boxes which are packed in the ordinary sixteen-quart crate for shipment.

LIFE OF PLANTATION

With good care and proper pruning, currants and gooseberries may be kept in a profitable condition for many years, but it is better to set out new plants on a new site every eight to twelve years. The bushes will live and bear some fruit much longer than this, but they will not be as vigorous and productive as younger plants. The bushes become crowded and harder to manage as they get older and the fruit deteriorates in size. Young plants are so much more vigorous and productive that they soon more than repay the cost of planting. Old bushes in the home garden may sometimes be rejuvenated by cutting off all the canes close to the ground and giving a heavy application of well rotted manure.

INJURIOUS INSECTS AND DISEASES

There are many insects and diseases which attack the currants and gooseberries but fortunately only a few do sufficient damage to become seriously important in Michigan. Brief descriptions of the more common ones and measures for their control are mentioned here.

INSECTS

Approved by the Department of Entomology.

The most important insects injurious to the currants and gooseberries are the San Jose scale, currant borer, currant worm, and the currant plant louse.

San Jose Scale. This insect is often a serious pest on the currants and if left without any effort to control them soon kill the plants. The scales are about the size of a pin head and when badly infested the twigs have an ashy appearance. Currant bushes should be frequently inspected for this insect especially in localities where it is known to exist and if any are found, the bushes should be thoroughly sprayed early in the

spring before growth starts with commercial lime-sulphur solution diluted at the rate of one gallon to eight of water.

Currant Borer. Currants are often attacked by a borer which injures or kills the canes. In early summer a blue wasp-like moth lays eggs near the tip of the shoot. The white larvae or "grubs" bore into the stem and then burrow down through the pith. They become nearly full grown by fall, and winter over in the canes. The infested canes put out a sickly foliage the following spring.

Control. Cut out and burn the infested canes when pruning in the spring. Do not allow very old canes to remain on the plant.

Currant Worm or Currant Sawfly. This is a common pest of the currant and gooseberry. A small fly lays eggs on the under side of the leaves, the larvae or "worms" are at first white, later green with black spots and finally green tinged with yellow. When full-grown they are nearly three-fourths of an inch in length. They feed on the leaves and when nearly full grown are very destructive, and will strip a bush in a few days. Currant and gooseberry bushes should be examined often especially the lower leaves where they first appear.

Control. Early in the season they may be destroyed by spraying with one pound of arsenate of lead powder or two pounds of the paste in 50 gallons of water; or calcium arsenate powder, 1 part to 5 or 6 of flour or hydrated lime, applied with a "dust gun" is very effective.

Currant Plant-Louse. The leaves of currants and gooseberries are often attacked by green soft-bodied lice which feed on the under surface of the leaves. They appear early in the season but often are not noticed until much damage is done. The leaves become curled and distorted and the upper surface turns a bright red.

Control. The insects can be killed by spraying if it is done early before the leaves begin to curl. Tobacco extract (40% nicotine sulphate) used at the rate of one fluid ounce to 8 gallons of water, in which 4 ounces of laundry soap has been dissolved, is the best remedy. It is very important to spray the under side of the leaves thoroughly, and each insect must be hit with the solution to kill it.

DISEASES

Approved by the Department of Botany.

Gooseberry Mildew. This is a common and most serious fungous disease affecting the gooseberry. It attacks the English varieties especially. It sometimes attacks the American varieties and occasionally the currants. It is first noticed on the young leaves and new growth and then spreads to the young fruits. All the diseased parts are covered with a white powdery substance which later in the season turns brown and thickens forming a dense felty coat over the affected parts. The whole plant may be seriously checked or even killed by the successive attacks.

Control. Can be controlled by spraying with 4-4-50 Bordeaux mixture or commercial lime-sulphur diluted, 1 gallon to 40. Make the first application when the buds open and later every ten days until at least five applications have been made.

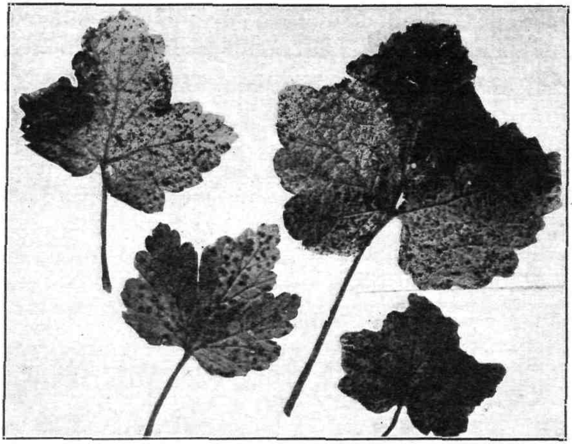


Fig. 5.—Anthracnose on currant and gooseberry leaves. (Courtesy of Botanical Department.)

Anthracnose. This is a fungous disease which is also known as leaf spot or leaf blight. Small dark brown circular spots are produced on the leaves chiefly on the upper surface. The leaves become a sickly yellow color and fall off early which prevents the proper ripening of the wood and the formation of fruit buds for the next year.

Control. Bordeaux mixture 4-4-50 or lime-sulphur solution 1-40 is very effective. Make the first application when the leaves are unfolding and later at intervals of 10 to 20 days until 5 or 6 sprayings have been made.

SPRAYING

Disease and insect pests of the currant and gooseberry appear each year and systematic annual spraying with the proper materials is necessary to secure best results. The materials used for the treatment of insects and diseases may be so combined that one spraying will answer for both and if properly applied at the right time very little trouble should be experienced in keeping them under control. The following program is recommended as a general treatment for these fruits.

If *San Jose Scale* is found, spray *before growth starts* with commercial lime-sulphur solution diluted one gallon to eight or ten with water.

Just as the leaves are expanding, spray with 4-4-50 Bordeaux mixture or commercial lime-sulphur (diluted 1 gallon to 40) and 2 pounds of lead arsenate paste, or 1 of the powder to every 50 gallons.

If the *Currant Plant-Louse* is present, add one-half pint of Black Leaf 40 to each 50 gallons of mixture.

Repeat this spraying when the fruit is about one-fourth grown.

If worms trouble after this, use fresh hellebore, 1 ounce to 1 gallon of water or as a dry application 1 pound in 5 pounds of flour or hydrated lime.

If the *Anthracnose or Gooseberry Mildew* are troublesome, make additional sprayings with dilute lime-sulphur or 4-4-50 Bordeaux mixture every ten days or two weeks until near picking time and another immediately after the fruit is picked.

VARIETIES RECOMMENDED

GOOSEBERRIES

The American varieties are grown much more extensively than the English varieties in this country. They are comparatively free from mildew and usually more productive. The leading varieties are the *Downing, Houghton, Pearl,* and *Josselyn.*

The *Downing* is the most important commercial variety. The bushes are strong, vigorous growers and very productive. The fruit is of good size and yellowish-green in color. Excellent in flavor and quality. One of the best.

The *Houghton* is a very profitable variety. The fruit is of medium size and pale red in color, but is not as large and attractive as that of the Downing. The bushes are very vigorous and productive, and free from disease.

The *Pearl* is a cross between the Downing and an English variety. It very closely resembles the Downing and is highly recommended. In some places is superior to the Downing.

The *Josselyn* (American Red Jacket) is very prolific and a vigorous grower. The berries are medium to small in size, pale red in color and of good flavor and quality. One of the best red varieties.

The English varieties are not grown extensively in this country on account of their susceptibility to mildew. They are not as productive as the American varieties, but the fruit on most of the varieties is large and attractive in appearance. The following varieties are recommended:

Industry. One of the best known of the English varieties. The bushes are vigorous and quite productive. The fruit is very large, dark red

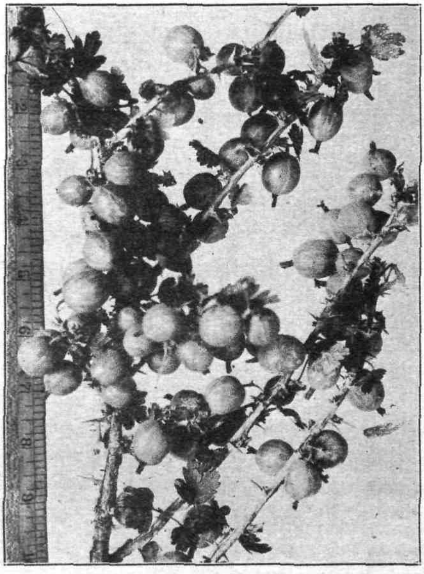


Fig. 6.—Downing.

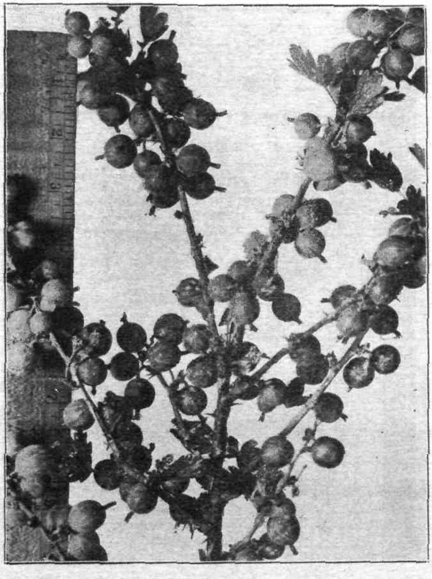


Fig. 7.—Pearl.

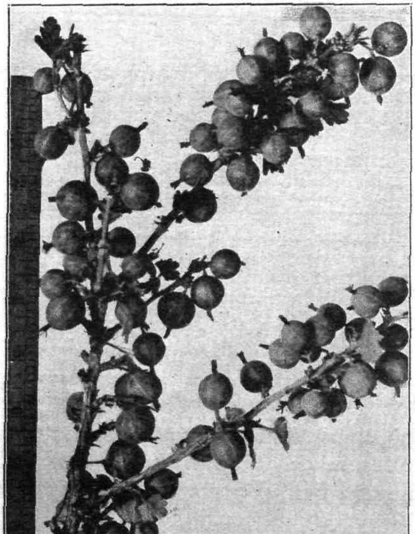


Fig. 8.—Houghton.

when ripe, and quite hairy. Supposed to be somewhat more free from mildew than other English sorts.

Chautauqua. The bush is very vigorous and productive. The fruit is very large, smooth, pale green in color and of very best quality. One of the best for home use.

Columbus. Bush upright, vigorous and fairly productive. Fruit large, smooth, greenish yellow. Very good. Quite free from mildew. Considered one of the healthiest of the English varieties.

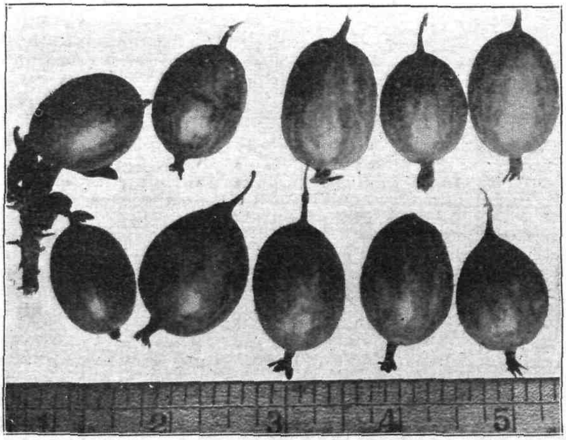


Fig. 9.—Industry.

RED CURRANTS

Perfection. A comparatively new variety which has become very popular among the growers in the State. The berries are large, bright red and are borne on medium-sized well-filled clusters. The bushes are strong growers, somewhat spreading and very productive. One of the best for home or market purposes.

Fay (Fay's Prolific). A well-known market variety on account of its productiveness and large handsome berries. Early. Does best on a heavy soil.

London Market. A well-known variety which has been quite extensively planted in the state. The bushes are tall, slightly spreading, very vigorous and productive. Berries medium in size, dark red, quality good.

Red Cross. One of the newer varieties which is desirable on account of the large size of the fruit and its productiveness. The bushes are tall, vigorous and very healthy. The berries are bright red, juicy, and have a mild, pleasant flavor.

Red Dutch. One of the oldest varieties and still grown by some; very productive but not desirable on account of the small size of the fruit.

Prince Albert. A good late variety which is a favorite with many growers but is not generally grown. It is a strong grower and productive. The fruit is medium in size, light red and is borne in short, well-filled bunches.

Wilder. A very strong and vigorous grower and quite productive. The fruit is large and attractive in appearance. Ripens about the same time as the Fay but hangs on well for late picking.

BLACK AND WHITE CURRANTS

The black and white currants are little grown in the state. There is practically no demand for them on the markets and they are not recommended for planting except for home use. The fruit of the white currants is generally milder in flavor than that of most of the reds, but does not make an attractive jelly. The *White Grape* is probably the most satisfactory variety of this type. The black currants are generally unproductive and the strong musky odor is disagreeable to many. They make good jams and jellies and are highly appreciated by those who have learned to use them. *Black Champion* is one of the best varieties.

FOUL-BROOD

Circular No. 39

Supplement to Special Bulletins Nos. 58 and 64

BY B. F. KINDIG

In addition to the subject matter treated in Special Bulletins numbers 58 and 64, we desire to add the following information relating to the cure or control of European foul-brood. Attention is especially directed to the disease resistant qualities of the best grade of Italian stock. Among them foul-brood does not cause serious damage in such colonies as are kept strong at all times and there is a gradual decline in the number of colonies affected in yards where the best bee-keeping practices are in operation.

The Italian race of bees is the only one which has proved itself resistant to European foul-brood and is, also, the most tractable and at the same time the most profitable from the standpoint of honey production. The disease is widely scattered over the state and the predominating race of bees is so largely Black, that it seems at present, that the most vital need of Michigan bee-keepers is the eradication of the Black bees and the complete Italianization of all colonies. Not all Italian queens come from colonies or apiaries of resistant stock. Beekeepers should not purchase their queens except from reliable breeders. After testing a number of queens in the yard for a year in order to observe which are the most resistant to disease; which are most tractable; and which are most profitable from the standpoint of production; then, the one queen which measures up in the highest degree to the standard set should be used as a queen-mother from which to rear sufficient young queens for requeening the entire yard and all other colonies in the neighborhood. Unless the colonies in the vicinity of the apiary are also requeened, the stock is likely to soon degenerate because of the admixture of Black blood. A few queens should be purchased from year to year from reliable breeders, and should be carefully tested along with those reared in the yard and any other breeding queens selected.

When colonies of Italian bees are allowed to become weak, then the characteristic resistance is greatly diminished or lost. Therefore, strength of colony is a matter equally as important as Italian blood but does not at all take the place of Italian stock. Strength of colony and Italian stock must both be present in all colonies at all times in order to successfully resist or eradicate European foul-brood. When the disease is present in an apiary of Black or hybrid blood, Italianizing and the doubling up of weakened colonies until strong colonies are made, should be done at the same time and at the very earliest opportunity possible in order to bring the disease under control. If it is necessary to wait for some time in securing the Italian queens, then it is recommended that the Alexander Treatment hereafter described be used.

No method of handling the disease from year to year can be successful unless that method takes cognizance of and embodies within it the best *recognized and established principles of good beekeeping.* A number of the best beekeepers in the state give but little attention to European foul-brood from year to year because they have in their yards selected *Italian stock and practice the best known methods of beekeeping.* In this connection it may be well to mention a few essentials of good beekeeping: viz. pure Italian stock of greatest vigor and productiveness, no queens over two years of age at any time, the wintering of the bees so well that the colonies are strong and vigorous in the early spring, and an abundance of stores at all times.

METHOD OF TREATING EUROPEAN FOUL-BROOD

The Miller Treatment.—The following is quoted from Dr. Miller in the "ABC & XYZ of Bee Culture"; "First, no matter whether the case be severe or mild, make the colony strong. In a severe case, kill the queen; and as soon as the colony recognizes its queenlessness, say within 24 hours, give a ripe queen cell, or, immediately at the time of killing the queen, give a virgin not more than a day old or a cell in a protector. That's all; the bees will do the rest. In a mild case, make the colony strong, and cage the queen in the hive *for a week or ten days—only* that. But don't expect the disease to be at once and forever stamped out. Last year I had the disease in a mild form in about one colony in *four; this year in about one in twenty.*"

In classifying various degrees of severity of an attack of European foul-brood, Dr. Miller stated the following recently in an editorial: "If less than one per cent of the larvae are diseased, it is a very mild case; if one to ten per cent, mild; 10 to 35, medium; 35 to 50, bad; and beyond 50, very bad."

Dr. Miller further states in response to the question: "What do you do to save the combs?" "Nothing. Just use them the same as if there had been no disease. Vigorous bees with a vigorous queen will clean them out. Spores may be left, and here and there the disease may break out again; but in the long run the loss will be less than if the combs were destroyed, and possibly the returns of the disease will be no more frequent than if all combs were destroyed. In my own apiary I think there were no more fresh outbreaks where the old combs were left than where the bees were thrown upon foundation."

This treatment is not to be used in apiaries of Black or hybrid bees. The colonies must be vigorous Italians or be given a cell or queen from vigorous Italian stock before one can expect to make progress against the disease.

Alexander Treatment.—Double up all diseased colonies until strong colonies are secured. Kill the queens and keep the colonies queenless for 20 days. Then introduce into each a ripe cell or a recently hatched virgin. Such a long period of queenlessness is not necessary except in colonies where the disease has progressed to the point where most of the larvae are dead. The period of queenlessness should be determined by the length of time it takes a colony to clean out ALL of the diseased, dead larvae. When the combs are free from such dead larvae, then it is

safe to introduce a cell or a virgin queen. In colonies where only a dozen or so larvae are affected, the caging of the queen for a few days usually controls the disease.

McEvoy Treatment together with Requeening.—This treatment is described in Special Bulletin 64, page 4, under the heading of "European foul-brood." This method of treatment is obsolete and should not be considered or practiced unless both of the methods described above have proved unsatisfactory. In that case, get in touch with the State Inspector of Apiaries, East Lansing, Mich.

B. F. KINDIG,
Department of Entomology.

INFECTIOUS ABORTION AND STERLITY IN CATTLE*

Circular No. 40

BY E. T. HALLMAN, ANIMAL PATHOLOGIST.

It is believed that abortion is most frequently introduced into the herd through the purchase of pregnant or recently freshened cows although it may be introduced by breeding to a neighbor's bull, and perhaps in other ways not yet fully understood. Newly purchased females, though they do not abort, may be carriers of the infection.

When abortion manifests itself in a herd, immediate steps should be taken to ascertain if it is infectious. This is best determined by a blood examination. Any one may have this test made by sending about one ounce of blood from each animal to be tested to the Bacteriological Department, East Lansing, Michigan.

When abortion first manifests itself in a herd many dairymen are tempted to sell for beef the aborting animals, thinking that the infection may be eliminated in this way.

It is not advisable to attempt to eliminate the infection in this way. There are two reasons why this is so. First, the extent of infection in a herd cannot be measured by the number of abortions since many infected animals carry their calves to maturity; and second, when many animals are sold for this reason it becomes necessary to purchase new animals to maintain the herd, and in so doing one is likely to introduce a more virulent strain of infection than already exists. If aborting animals are properly handled they may develop into regular breeders and should not be sold simply because they have aborted.

There are no known cures for abortion. Many proprietary preparations are to be found upon the market, both medicinal and the so-called bacterins and serums, but none of these have proved sufficiently effective to warrant their recommendation.

There are no measures by which the infection can be completely and surely eliminated from a herd other than disposal of the entire herd. It is more likely that once the infection is introduced, it will remain more or less indefinitely, but this characteristic of abortion should not discourage one from going on with the cattle business.

There are measures by which one may reduce the percentage of abortion to such an extent that dairying and calf production may be made profitable. There will perhaps be a few abortions each year but its ravages may be checked. There are no easily applied measures, but ones which require persistent effort, not for a week or a month but for the entire time that one remains in the business of producing milk and calves. The only measures that have proved effective are stable hygiene and disinfection.

To enable one to most effectively apply these measures one should know the ways by which the abortion bacilli are eliminated from the

*Adapted from numbers 1, 2 and 3 of Quarterly.

infected cow and the ways by which the micro-organisms enter the body of the susceptible cow. The discharges from the uterus and the milk are the most important of the former, and with the feed and water and by the bull and direct contact with the floor the most important of the latter. In fighting abortion one must aim to kill the micro-organisms as they leave the infected cow on the one hand and protect the feed and water and the bull against infection on the other.

There is no practical and certain way of determining the exact number of infected animals in a herd and, if there were, the conditions would not be the same a few months later. Further, an infected animal that gives birth to an apparently normal calf at full term may be as great a source of danger to yet uninfected animals as though abortion had occurred. For these reasons, in adopting control measures that will prove most effective, one must apply these measures to all animals of breeding age.

Daily disinfection of the hind parts of all non-pregnant females of breeding age should be practiced until the animals are safely in calf. There are two reasons for this. First, the uterine discharges from infected animals are constantly soiling the hind parts and udder of the cow and the barns and lots, and the infection frequently reaches the uterus of non-infected cows through contamination of the external genitals from infected animals and from infected floors.

With a pail of some good reliable disinfectant of sufficient strength and a brush, one should systematically wash the buttocks, thighs, root of tail, external genitals and udder daily, until the animal is known to be with calf. In addition to this the gutter and floors of barn should be cleaned daily and sprayed with an effective disinfectant. A thirty-gallon spray mounted on two wheels, for convenience in moving from one part of the barn to another, should be a part of the equipment of every dairy barn.

Since the udders of a high percentage of infected cows are infected, the first few streams of milk should not be milked on the floor of the barn as is practiced in some herds, where it is desired to keep down the bacterial count of the milk. A separate container should be provided for this and disposed of outside of the dairy barn. The practice of disinfecting the udder and floor daily should be applied at all times, but it is probably safe to discontinue disinfection of the other parts of the cow when it is known that she is safe in calf, until approaching abortion or calving.

Several days before a cow is to be bred, the vagina should be douched daily with three ounces of borax to one gallon of warm water, using about one gallon of the solution for each douche. This is more conveniently done by suspending a wire over the gutter, two or three feet higher than the posterior parts of the cow, on which may be hung an ordinary fountain syringe. This is connected with four or five feet of rather stiff rubber tubing about one-half to five-eighths inch in diameter. (A pure gum horse stomach tube is very useful for this purpose. Your veterinarian can get it for you.) This is inserted as deeply into the vagina as possible in order to thoroughly cleanse the mouth of the uterus. After using the tube it should be allowed to remain in a pail of disinfectant three or four minutes to disinfect it before using on another animal.

The sheath of the bull should be irrigated before and after service with borax solution and the lower surface of the belly cleansed with the disinfectant used for disinfecting the external parts of the cow. To irrigate the sheath use a fountain syringe attached to a pure gum horse urinary catheter. (Have your veterinarian get it for you.) The end of the catheter should be inserted three or four inches into the sheath, *grasping the skin around the catheter with the left hand so that the* solution may be held in the sheath. Allow the sheath to become moderately distended with the solution and with the right hand gently massage the sheath, forcing the solution into the folds of the sheath. After two to three minutes release the left hand allowing the shealth to empty itself. If this is repeated once or twice the sheath may be effectively cleaned. Very few bulls will offer any resistance to this treatment *if gently handled. In the case of a bad bull a special stock should be con*structed to hold him securely while being treated.

Two to three weeks before the animal is due to calve, resume the daily disinfecting of the external parts of the cow and a day or two before calving, or if signs of abortion manifest themselves remove the cow to a clean, well-lighted box stall, the floor of which has been previously disinfected and well supplied with clean bedding, and douche the vagina daily with three ounces of borax to one gallon of clean, moderately warm water.

After abortion or calving the afterbirth should be burned or buried out of the reach of dogs and the contaminated bedding either burned or carried to fields not used by cattle. The bedding should be changed and the stall disinfected as frequently as necessary to keep clean. As far as practicable, the attendant should stay out of the stall and the freshened cows should be the last milked to lessen the danger of carrying the discharges to other cattle on the feet or hands of the attendant. *Contamination of the feed with the discharges on the feet of the attend*ant is probably one of the most common ways of infecting animals.

The udder and hind parts of the cow should be cleaned daily with brush and disinfectant and the animal should not be returned to the herd until the uterine discharges cease. We do not recommend douching the vagina at this time, unless done under the recommendation and instruction of your veterinarian, because there is considerable danger *of infecting the uterus by improper methods of vaginal douching, and* unless complications arise demanding the services of a competent veterinarian, vaginal douching, even in cases of abortion, is not necessary.

In most herds affected with infectious abortion sterility, sooner or later, causes considerable losses. Sterility in the cow is most often due to disease of some one or more of the reproductive organs. In a few cases the cause may be found in the bull but, when this trouble is associated with abortion infection, the cause is to be looked for most often in the cow.

In most cases, diseases of the uterus or cervix (neck of uterus) is the primary cause, but occasionally disease of the ovaries and less frequently disease of the vagina is the cause.

There are various grades of diseased conditions of the reproductive organs causing sterility, ranging from slight affections, in which the animal comes in heat regularly, and appears quite normal to the un-

trained man, to serious affections in which there are marked accumulations of pus in the uterus or degeneration of the ovaries. Most of these conditions are due to bacterial infections. Work at this Station indicates that the abortion bacillus is not always the cause of these conditions, but that several different types of micro-organisms may be the active cause. There is no question but that the abortion bacillus is often a predisposing factor in that it enables other micro-organisms to become established. Whether the abortion bacillus or some other micro-organism is the cause, the results are the same; a mild or severe inflammation is set up causing sterility.

Treatment of these conditions is not so satisfactory from the standpoint of the average dairyman, as is prevention. There are several reasons why this is true. First, treatment of these conditions requires much skill on the part of the veterinarian. Few veterinarians have had the necessary training and experience to acquire this skill. This is no fault of theirs, since it has been only in the last few years that any studies have been made of the diseases of the reproductive organs of cattle. Second, to secure the services of a qualified veterinarian to administer treatment as frequently as is necessary requires too great an expenditure, except in the case of pure bred animals. Third, treatment is not always successful. There are perhaps two reasons for this. Many of the animals have been affected for so long that irreparable changes have occurred in the reproductive organs and it is probably a fact that we have not yet learned the best methods of treating the several conditions that are met with. This Station is now working upon this problem, and it is hoped that practical, effective measures will be worked out in the not distant future.

The fundamental principles involved in the prevention of sterility are the same as those in the prevention of abortion and have already been discussed. They are the same because the causative micro-organisms enter and leave the reproductive organs in much the same way. In addition to those preventive measures there are a few other measures that should be emphasized. In herds affected with contagious abortion, it is not safe to defer breeding animals any considerable time after calving or abortion. The statement has often been made that an aborting cow should not be bred for at least six to eight months after abortion. *There is no foundation for this statement. If an aborting cow cleans up* well after aborting it is better to breed her as soon as she begins to come in heat regularly. Not to do so may result in her acquiring some infection leading to permanent or temporary sterility. Each succeeding heat period affords an opportunity for infection to become established in the reproductive organs as some of the changes associated with this period favor infection. An aborting cow, or one that has calved normally, should not be bred as long as there is any discharge from the uterus, but just as soon as she is in a normal condition, she should be bred.

Failure to breed is often the result of retention of the afterbirth or improper methods of removal of the afterbirth. This is one of the most serious affections of the uterus and one requiring great skill to properly treat. It is usually due to infection in the uterus, not necessarily the abortion bacillus, but other disease-producing micro-organisms as well.

When this complication arises in valuable animals, breeders should secure the best of veterinary service to treat it.

Failure to come in heat in a reasonable time (six to eight weeks) after calving is usually due to disease of some one or more of the reproductive organs and an effort should be made to determine the cause and correct it if possible. Disease of the reproductive organs are more effectively *treated if treatment is started early, than if allowed to run on for months* before an effort is made to correct them.

Failure "to catch," after two or more services at regular intervals, is usually due to some disease of the reproductive organs. The cause should be determined and removed if possible. Repeated service under such conditions tends to aggravate the condition.

Continuous "heat" or irregularity in the "heat periods" is usually an indication of ovarian trouble and should be treated at the earliest possible time.

No general treatment of disease of the reproductive organs can be outlined, but each case must be carefully examined and the treatment determined by the condition. Best results will be obtained if an early diagnosis is made and treatment applied. Long standing cases usually fail to respond. For economic reasons, the treatment for sterility is applicable only to highly valuable animals, but even in these prevention is worth more than treatment.

INTRODUCTION.

Much interest has been manifested in the soluble constituents of the soil for nearly three-fourths of a century, as a result of which many valuable contributions to our knowledge of the subject have been made. Yet a critical examination of the available literature has led to the conclusion that this fundamentally important subject still remains a fertile field for investigation, new and improved methods of attack being especially desirable. Such phases as the rate of solution of soils under different conditions of moisture, temperature, cropping, and season as well as the immediate and residual effect of salts upon solubility should be investigated, and moreover, information concerning the concentration of the soil solution under field conditions as affected by season, diffusion, water movements, tillage and cropping is very desirable. In view of the situation the soil solution is receiving much attention by members of the Soils Section of the Experiment Station. Bouyoucos is engaged in researches on the rate and extent of solubility of soils under different conditions and treatments, mainly from the physical side, while Spurway is conducting very comprehensive chemical studies of the effect of soluble salts on the solubility of soils. In this report are presented data bearing upon the effect of salt movements, moisture, temperature and cropping upon the salt content of several soil classes.

The writers are greatly indebted to A. G. Weidemann for valuable assistance rendered throughout these investigations.

SOLUBLE SALT CONTENT OF SOILS AND SOME FACTORS AFFECTING IT.

Technical Bulletin No. 43

BY M. M. M'COOL AND C. E. MILLAR.

SALT MOVEMENT.

Salt movements affect the concentration and composition of different layers of soil. By means of the freezing point method (1) it was shown that the translocation of added salts in soils is appreciable even in the absence of moisture movements, the water content and the mass of salt present being very important considerations. Moreover, data were presented which show that an application of a given salt at one point in the soil may release another which in turn may be translocated to an adjacent layer of soil (2).

In these studies 300 grams of medium sand and silt loam respectively were treated with 1% sodium chloride and placed in the bottom of 3 gallon jars and the filling completed with untreated moist soils. One set was unsealed in order to permit loss of water by evaporation. The depression of the freezing point of the different layers of soil and the amount of certain bases found in the water extracts of the same are given in table 1.

TABLE 1.—CHANGES IN THE COMPOSITION OF THE SOIL SOLUTION INDUCED BY THE ADDITION OF ONE PER CENT SODIUM CHLORIDE TO A MEDIUM SAND AND A SILT LOAM. *DURATION 15 DAYS.*

Distance from salt layer.	Medium sand, containg 9 per cent of water				Silt loam, containing 20 per cent of water.			
	Freezing point lowerings of soil.	Iron and aluminum.	Calcium.	Magnesium.	Freezing point lowerings of soil.	Iron and aluminum.	Calcium.	Magnesium.
Inches.	°C.	Parts per million.	Parts per million.	Parts per million.	°C.	Parts per million.	Parts per million.	Parts per million.
4	0.042	No appreciable changes.	+124.6	+6.90	0.002	No appreciable changes.	+14.6	+5.58
3	.077		+74.3	+6.50	.050		+45.8	+11.50
2	.117		+51.7	+4.28	.322		+148.9	+19.95
1	.140		+26.7	+3.27	.522		+103.4	+12.70
0	.277		+39.4	+1.31	.687		+89.8	+9.47
CLOSED CONTAINERS. DURATION 25 DAYS.								
3	0.002	+3.60	+3.60	+0.48	.000	....	13.4	4.5
2	.015	+3.40	+27.08	+4.21	.045	....	35.0	10.2
1	.085	+1.20	+12.01	+1.79	.65	....	120.0	22.0
0	.225	+4.60	+2.80	+.26	.85	....	148.5	15.5

(1) Bouyoucos, G. J. and McCool, M. M. 1915. The Freezing Point Method as a New Means of Measuring the Concentration of the Soil Solution Directly in the Soil. Mich. Agr. Expt. Sta. Tech. Bul. 24, 44 pp.

(2) McCool, M. M. and Wheeting, L. C. 1917. Movement of Soluble Salts Through Soils. In Journal of Agricultural Research, Vol. XI. No. 11, p. 531-547.

More recently colorimetric methods have been employed. Fine sand was treated with normal potassium hydrate, a two-inch layer placed in the bottom of test tubes one inch in diameter and two inches in length. The tubes were then filled, with a portion of the sand that had previously been moistened with phenolpthalein indicator, permitted to become dry and then moistened with distilled water. In this manner the rate of diffusion was readily determined. Typical examples of the results obtained are given in table 2.

TABLE 2.—DIFFUSION IN FINE SAND.

Period days.	5 per cent. water.	10 per cent. water.
First day	3.5 m. m.	10 +m. m.
Second day	2.5 m. m.	5 m. m.
Third day	2 m. m.	3 m. m.
Fourth day	1. +m. m.	2 m. m.
Fifth day	1. m. m.	2 m. m.
Total	10. +m. m.	22 m. m.

The above data show that the rate of diffusion although slow increases with the water content of the sand and decreases with an increase in *distance from the deposit. Attention should be called to the possibilities* for development of the method to be used as a laboratory experiment in soil physics.

The *translocation of salts as affected by film water movement* has also received consideration. In these investigations galvanized iron containers four inches in diameter were employed. Salt treated layers six inches *in thickness were placed at different depths from the surface in order* to throw some light upon the relation between surface and subsoils in this respect. In addition the salt was uniformly distributed throughout the soil column.

TABLE 3.—MOVEMENT OF SALT THROUGH SILT LOAM 12 INCHES FROM SURFACE DURATION OF EXPERIMENT 32 DAYS.

TREATED SOIL.

Depth from surface.	Water content, per cent.	Depression of freezing point.
¼ inch	3.9	.570
1 inch	9.3	.113
4 inches	17.3	.075
8 inches	18.4	.395
11 inches	....	1.185
15 inches	18.5	1.075
19 inches	20.4	1.14
24 inches	20.2	.065

UNTREATED SOIL.

Depth from surface.	Water content, per cent.	Depression of freezing point.
¼ inch	4.5	.578
1 inch	10.2	.055
6 inches	18.2	.053
15 inches	20.0	.058
24 inches	20.3	.070

An examination of the above table reveals that the water content of *the soil was not markedly reduced between the fourth and fifteenth inch* layers. Moreover the upward translocation was confined to the region below the fourth inch layer of soil. The high concentration of the surface layer was due to the translocation of the soluble material originally present or formed in the soil as evidenced by the condition found in the untreated containers.

Another series was run wherein the salted layer was placed 24 inches from the surface. Inasmuch as the film movement did not take place more than fifteen inches from the surface the movement of the added salt which was confined to the section below this, was due to diffusion as the data set forth in table 4 show.

TABLE 4.—MOVEMENT OF SALT IN SILT LOAM 24 INCHES FROM THE SURFACE DURATION OF EXPERIMENT 32 DAYS.

Depth from surface.	Water content, per cent.	Depression of freezing point.
¼ inch	3.4	.562
1 inch	13.8	.065
15 inches	21.0	.055
23 inches	20.8	.770
27 inches	20.4	1.70
32 inches	21.8	.090
37 inches	21.6	.056

Similar studies were conducted with muck. The translocation of the salts that were placed twelve inches from the surface was found to be as presented in table 5. In this case the salt had moved upward to the sixth inch layer, but had not passed to the bottom of the tube.

TABLE 5.—MOVEMENT OF SALT IN MUCK SOILS. DURATION OF EXPERIMENT 35 DAYS.

Depth of sample.	Untreated.	Salt 12 inches from surface.
	Freezing point lowering.	Freezing point lowering.
¼ inch	.740	.746
1 inch	.138	.135
4 inches	....	.070
6 inches	.090	0.16
8 inches	....	.560
12 inches	....	2.10
15 inches	.082	1.420
19 inches	....	.360
24 inches	.084	.07

The results obtained from medium sand are of interest.

The sand contained four per cent moisture when placed in the cylinders, preliminary studies having revealed that downward translocation of the water resulted with higher water contents. The salted layers were placed six and twelve inches from the surface respectively. The experi-

ments were conducted from July 10 to September 4. The freezing point lowerings of the samples of soil taken from the treated and untreated soil are shown in table 6.

TABLE 6.—MOVEMENT OF SALT IN MEDIUM SAND.

Soil.	Untreated.	Salt, 6–12 inches from surface.	Salt, 12–18 inches from surface.
Depth of sample in inches.	Freezing point lowering.	Freezing point lowering.	Freezing point lowering.
¼ inch	*.030*	.022	.030
1– 2 inches	.020	.193	.012
2– 3 inches	.012	.250	.014
3– 4 inches	.012	.120	.043
4– 5 inches	.007	.127	
5– 6 inches		.104	.100
7– 8 inches			.135
8– 9 inches		.076	
9–10 inches	.008		.163
11–12 inches			.259
12–13 inches		.020	
14–15 inches	*.005*	*.017*	.200
16–17 inches		.007	
17–18 inches			.050
18–19 inches		.007	
19–20 inches	.007		.021
23–24 inches	.007	.007	.015
25–26 inches			.009
30–33 inches			.007
33–36 inches			.008

Some of the salt that was placed six inches from the surface accumulated in the second layer of soil but not in the surface. Whereas the change in concentration of the soil solution was inappreciable three inches from the surface in the tube in which the salt was placed twelve inches from the surface. In the former case the soil became dry on the surface before the salt reached this point and in the latter the dry layer or mulch was formed to a depth of about four inches, thus preventing higher translocation of the soluble material.

The effect of the depth to water table upon the salt content of soils has been investigated in the laboratory. Four cylinders were filled with each of the soil classes studied, placed in larger containers which were filled with water to sufficient height to bring the water table to the surface of the soil. After the water table had reached the surface two grams of sodium chloride were added to two of the containers. After a period of forty-seven days the treated and untreated soils were sampled at different depths and the freezing point lowerings determined. The rate of evaporation was high inasmuch as the experiments were run from July 19 to September 4, the containers being exposed to sunshine and to wind movements.

TABLE 7.—EFFECT OF WATER TABLE UPON THE SALT CONTENT OF SOILS.

Depth of sample.	Freezing point lowerings.					
	Medium sand.		Fine sand.		Clay loam.	
	Untreated.	Salted.	Untreated.	Salted.	Untreated.	Salted.
¼ inch	.030	.075	.033	.479	.327	....
¼-1 inch	.002	.030	.010	.184	.046	.546
2-3 inches	.002	.030	.004	.149	.016	.040
4-5 inches	.003	.029	.004	.070	.016	.030
6-7 inches	.002	.019	.003	.005	.007	.010

These results show that soluble salts diffuse downward very slowly in fine textured soils and more rapidly in sand, where the water table lies at the surface and where the rate of evaporation is high. To what extent this affects the quantity of soluble constituents of soils under field conditions remains to be determined, yet the indications are that it is appreciable. The time factor and the rate of evaporation from the *surface must be taken into consideration.*

Where the water table stood within seven inches of the surface the downward movement of the salt was again more rapid in the sand than in the fine textured soils as shown by the data set forth in table 8.

TABLE 8.—EFFECT OF WATER TABLE SEVEN INCHES FROM THE SURFACE ON SALT MOVEMENTS. DURATION OF EXPERIMENT 43 DAYS.

CLAY LOAM

Depth of sample.	Untreated Soil. Freezing point lowering.	Salted Soil. Freezing point lowering.
¼ inch	.680	3.50
1-2 inches	.070	.372
3-4 inches	.040	.076
5-6 inches	.040	.056
6-7 inches	.026	.024
MEDIUM SAND.		
¼ inch	.053	.362
3-4 inches	.037	.053
6-7 inches	.016	.067

In the next series the water table was maintained twelve inches from the surface. Under these conditions the downward translocation was found to have taken place more rapidly in the clay loam than in the sands. The results obtained are presented in table 9.

TABLE 9.—THE EFFECT OF WATER TABLE (TWELVE INCHES FROM THE SURFACE ON SALT MOVEMENT. DURATION OF EXPERIMENT 43 DAYS.

Depth of sample.	Untreated Soil. Freezing point lowering.	Salted Soil. Freezing point lowering.
CLAY LOAM		
¼ inch	1.025	3.3
4 inches	.030	.128
8 inches	.045	.070
12 inches	.030	.050
FINE SAND.		
¼ inch	.190	3.45
4 inches	.020	.059
8 inches	.020	.051
12 inches	.015	.025
MEDIUM SAND.		
¼ inch	.024	3.30
4 inches	.016	.022
8 inches	.017	.015
12 inches	.015	.017

Still another series was run in which the water table was maintained twenty-four inches from the surface. The salt remained very near the surface inasmuch as the freezing point lowering of the soil four inches from the surface were the same in both treated and untreated soils of the same class.

RAINFALL AND SOLUBLE SALT CONTENT OF SOILS.

The rainfall affects the amount of soluble salts in the soil. The rate at which different added salts are removed by washing as well as their residuary affect upon the soluble constituents of the soil has been extensively investigated by Bouyoucos, the results of which are in the press. In this report however, are given the results of certain studies of the effect of rain upon the salt content of the soil under field conditions. Samples of soil have been taken before and after rains. In addition the effect of different amounts of added water has been considered.

The data in table 15 shows that a two-inch rainfall on muck lands that are slightly below the optimum water content for plant growth greatly reduces the salt content of the surface layer and takes portions of it a few inches below, yet there still remains appreciable quantities in the surface layer of soil. Samples were also taken from several soil classes, where the growth of vegetation was prevented, before and after 1.3 inches of rainfall. The effect of this amount of precipitation was found to be measurable as the data in table 10 show.

TABLE 10.—EFFECT OF A 1.3 INCH RAIN FALL ON THE SOLUBLE SALT CONTENT OF VARIOUS SOIL LAYERS IN DIFFERENT SOIL CLASSES.

DEPTH OF SAMPLES.

Soil class.	Freezing point depressions.					
	Before a rainfall.			After 1.3 in. rainfall.		
	¼ in.	¼ to 6 in.	6 to 12 in.	¼ in.	¼ to 6 in.	6 to 12 in.
Miami sand, cultivated	043	.001	.000	.008	.013	.012
Miami sand, virgin	.023	.004	.001	.010	.012	.015
Miami sandy loam, cultivated	.255	.005	....	.020	.029	.011
Miami sandy loam, virgin	.028	.005	.004	.016	.018	.012
Clyde sandy loam, virgin	.023	.009	.011	.028	.016	.011
Miami silt loam, cultivated	.041	008	.014	.027	.040	.022
Miami silt loam, virgin	.018	.006	.007	.012	.027	.015
Muck, virgin	.034	.005	.009	.021	.015	.023
Miami silt loam, cultivated	.014	.006	.002	.011	.015	.010
Miami very fine sandy loam, cultivated	.101	.015	.010	.018	.013	.018

Moreover certain soil classes whose salt content was known were irrigated with different amounts of distilled water. After the applications, they were sampled to different depths and the freezing point lowerings again determined. Typical results obtained from sandy loam are given in table 11.

TABLE 11.—EFFECT OF PERCOLATION UPON THE SOLUBLE SALTS IN SANDY LOAM SOIL.

Depth of sample.	Freezing point lowerings.		
	Untreated soil.	Soil receiving 3 inches of water.	Soil receiving 12 inches of water.
¼ inch	.015	.010	.003
1–3 inches	.018	.006	.005
3–6 inches	.010	.003	.004
9 inches	.004	.013	.002

As was expected the soluble salts of light loams are greatly reduced by a three-inch application of water and 12 inches reduces them to a very low percentage.

A heavy silt loam and a medium sand were also utilized. In studying the former tests were made on a level and uniform area in a corn field. (The corn was two inches in height.) Three inches of water greatly reduced the soluble salt content of the surface soil having little effect upon the adjacent layer, but the twelve inches of water greatly reduced the salt content in the upper nine inches of soil.

TABLE 12—EFFECT OF PERCOLATION OF WATER UPON THE SALT CONTENT OF SOIL

Depth of sample.	Freezing point lowerings. Untreated Soil	Soil receiving 3 inches Water	Soil receiving 12 inches Water
Silt Loam.			
¼ inch	.097	.006	.006
1–3 inches	.024	.012	.007
3–6 inches	.016	.014	.004
9 inches	.013	.017	.005
Medium Sand.			
4 inches	.015	.002	.003
1–3 inches	.018	.004	.005
3–6 inches	.010	.008	.005
9 inches	.004	.013	.002

In case of the medium sand 3 inches of water removed practically all of the soluble material to the nine-inch depth and samples taken after twelve inches of water had been added showed freezing depressions only slightly higher than distilled water.

EFFECT OF CROPS ON SALT MOVEMENTS.

Growing crops affect salt movement in soils. A number of samples were taken from soils occupied by spring grains, grasses, and meadows and adjacent areas upon which plant growth was prevented. In taking samples the surface was removed to a depth of one-fourth inch. At the time of sampling the rainfall had been inappreciable for thirty days.

TABLE 13.—EFFECT OF CROPS UPON SOLUBLE SALTS PRESENT IN SOILS.

Soil class.	Kind of crop.	Freezing point lowerings. Cropped.	Parts per million.	Bare.	Parts per million.
Silt loam	June grass	.020	500	.090	2,250
Sandy loam	Wheat	.017	425	.043	1,075
Silt loam	Oats	.025	625	.125	3,125
Sandy loam	Barley	.012	300	.050	1,250
Sand	Rye	.013	325	.016	400
Muck	Oats	.048	1,200	.842	21,050
Sand	Oats	.011	275	.014	350
Silt loam	Alsike, clover	.012	300	.020	500

In all except the sands the freezing point lowerings of the surface soils showed an accumulation of salts where the land was bare.

It seems that the difference between the cropped and uncropped soil in this respect is due to differences in water content, water movement, temperature, and to the removal of soluble constituents by the growing plants. The sandy soils studied, rapidly mulch themselves and consequently deposition of salts at the surface is prevented. If samples had

been taken just below the mulch it is probable that the freezing point lowerings of the bare soils would have been somewhat higher. Moreover, the soluble salt content of the sands was not great.

The effect of the growing crop is very local in this respect. Samples were removed at different distances from the growing plants in the bare soils in a number of cases. The results obtained as summarized in table 13 show clearly that the influence of the plants is not greatly felt beyond twelve inches, in some instances it extends over shorter distances. Moreover, the presence of nitrates usually accounts for more than one-half of the total solids as determined by the methods employed.

The nitrate content of a number of surface samples was determined. The samples were washed on a filter paper with distilled water until the leachings were practically constant in concentration as determined by the electrical bridge. The leachings were then evaporated to a small volume, transferred to Kjeldahl flasks and distilled with potassium hydroxide and Devarda metal. The total ammonia found was calculated to $Ca(NO_3)_2$.

TABLE 14.—SOLUBLE SALTS IN SURFACE SOILS.

DISTANCE FROM GROWING CROP.

Kind of crop.	1-4 inches.			8-12 inches			24 inches		
	Freezing point lowering °C.	Total solids. Parts per million	Nitrates as $Ca(NO_3)_2$. Parts per million	Freezing point lowering °C.	Total solids. Parts per million	Nitrates as $Ca(NO_3)_2$. Parts per million	Freezing point lowering °C.	Total solids. Parts per million	Nitrates as $Ca(NO_3)_2$. Parts per million
Wheat	.043	1,075	369	.043	1,075	492	.136	3,400	1,865.5
Wheat	.020	500	328	.043	1,075	553.5			
Alsike clover	.023	575	266	.026	650	205	.028	700	12[illegible]
Alsike clover	.016	400	246	.020	500	410	.020	500	34[illegible]

The amounts of soluble material in several muck deposits have been determined. We have repeatedly observed that salts accumulate on the surface during periods of drouth or low precipitation. Recently our attention was called to an unusual condition in a muck deposit near Potterville. It was reported that onions were growing very slowly in this particular soil although it was being cropped the first time. A visit to the area revealed that appreciable quantities of salts had accumulated on the surface, moreover the soil was moist. Samples were taken to the depths shown in table 15 and also a sample of water from a drainage ditch. When the first samples were taken the precipitation had been negligible the previous thirty days. A few days after sampling a two-inch rain fell and the area was again visited and samples taken. At this time the onions were growing with greater vigor than formerly. The results of the determinations are given in table 15.

TABLE 15.—SALT CONTENT OF MUCK.

Depth of sample.	Freezing point lowerings.			
	Before rain.	Parts per million.	After 2 inch rain fall.	Parts per million.
1–4 inch	1.47	36,750	.031	775
1–3 inches	.026	650	.035	875
3–6 inches	.015	375	0.20	500
6–9 inches	.014	350	.013	325
12–24 inches	.016	400	.015	375
24–30 inches	.016	400	0.14	350
Drainage water	.016	400	....	....

The high concentration of the salts at the surface indicated that the retarded growth of the onions was due to this factor. Accordingly samples were taken to the laboratory and Canada Field Pea seedlings placed in washed and unwashed soil. One part of the soil was washed with 5 parts of distilled water. The water content of the soil cultures was uniform and maintained so by daily additions according to the usual practice of conducting such studies. The cultures were placed in the east side of a well lighted laboratory. After ten days the seedlings were dead in the unwashed soil, no growth of roots having taken place while in the washed soil the roots had attained two and one-half inches in length with numerous laterals and the stems had grown to be two inches in length. We concluded from these results that the salt content in the surface layer of muck was too great for proper plant development.

The soluble salt content of samples taken from different layers of three muck deposits was determined. The results are reported in table 16.

TABLE 16.—SALT CONTENT OF MUCK SOILS.

Depth of sample.	No. 1.				No. 2.				No. 3.			
	Before rain.		After rain.		Before rain.		After rain.		Before rain.		After rain.	
	Freezing point.	Parts per million.	Freezing point.	Parts per million.	Freezing point.	Parts per million.	Freezing point.	Parts per million.	Freezing point.	Parts per million.	Freezing point.	Parts per million.
¼ inch	.077	1,925	.025	625	.272	6,800	.035	875	.134	3,350	.024	600
¼-3 inches	.023	575	.029	725	.052	1,300	.062	1,550	.032	800	.041	1,025
3-6 inches	.019	475	.017	425	.040	1,000	.042	1,050	.030	750	.032	800
6-9 inches	.016	400	.016	400	.028	700	.026	650	.026	650	.021	525
12-18 inches	.018	450	.019	475	.013	325	.012	300	.019	475	.017	425
18-24 inches	.020	500	.014	350	.011	275	.013	325	.015	375	.014	350
48 inches	.019	475	.018	450	.010	250	.009	225	.006	150	.007	175

The above results show that the soluble salt content of different muck soils is quite variable, especially in the upper layers and becomes quite high in some, several days after a rain. When it is considered that these determinations were made with saturated soils the conclusion that the concentration at medium or low water contents may become quite great and thereby injure plants, seems tenable.

Another interesting soil condition was found. Mr. Severance of Lansing reported that his tomato plants were developing very slowly regardless of the fact that they were properly watered and otherwise treated normally. The soil had been used for greenhouse purposes for eight years. A flat of plants was brought to our laboratory, an examination revealed that they were not diseased but showed characteristic development of plants grown in solutions of high osmotic pressure. The soil was sampled and the soluble salt content determined as usual. It was found to have a freezing point lowering of 0.115° which of course is several times greater than normal soils. He was advised to leach the soil by means of the garden hose. Later reports were to the effect that the plants grew in the flats that were so treated and developed at a more rapid rate than those that were watered as usual. We obtained a quantity of the soil and reduced the salt content of one portion by percolating distilled water through it. It was interesting to find that one inch of water removed much of the soluble salts from this soil.

TABLE 17.—REMOVAL OF SOLUBLE SALTS FROM GREENHOUSE SOIL.

	Soil.		Leachings.	
	Freezing point lowering.	Parts per million.	Freezing point lowering.	Parts per million.
Freezing point lowering of soil before leaching	.105	2,625	....	....
Freezing point lowering of soil after one inch of water	.035	875	.070	1,750
Freezing point lowering of soil after two inches of water	.024	600	.020	500
Freezing point lowering of soil after three inches of water	.022	550	.016	400
Freezing point lowering of soil after four inches of water	.020	500	.015	375

In making the extractions a two-inch layer of soil was placed in a tube 4 inches in diameter, brought to the saturation point and the above amounts of water passed through it. A nitrate determination of the soil revealed that it contained 2398.5 parts per million, or much of the total soluble salts was made up of nitrates.

Flats were then filled with the leached and unwashed soil, respectively, and tomato, lettuce and radish seed were sown. The germination of the seed in the former case was 75 per cent less than in the latter and at the end of 14 days the average heights of the plants were as given in table 18.

TABLE 18.—PLANTS GROWN IN WASHED AND UNWASHED GREENHOUSE SOIL.

Crop.	Height of plants.	
	Washed soil.	Unwashed soil.
Radishes	3 inches	1¾ inches
Lettuce	2½ inches	1½ inches
Tomatoes	1½ inches	1 inch

Inasmuch as the evaporation rate is rather high under greenhouse conditions, there is a tendency for the soluble constituents to accumulate at the surface unless the soils are watered frequently. If the soluble salt content is high this is certain to occur. It may be cited for example that the surface ¼-inch layer of soil in the flat revealed a very high concentration 24 hours after moistening, the freezing point depression being 1.35°, the soil being saturated with water when the determination was made.

DISCUSSION OF RESULTS.

Salt translocation in soils is due mainly to water movements. The data obtained from experiments in which water movements were prevented show that salts added to a soil move away from the point of high concentration and the rate is largely dependent upon the mass of salt present as well as the water content of the soil. Now in the field the total soluble salt content is relatively low and hence diffusion accounts for but local movements. The results of our studies of the freezing point lowerings of the surface layer of soils occupied by small grains and grasses and adjacent bare soils is further proof, yet it is probable that it operates to some degree in close proximity to the root hairs and aids in furnishing the plant with substances in solution.

When water movement takes place some of the soluble salt present is carried along with it. The results of the experiments where the soils were treated with substances in solution sufficiently near the surface to be within the zone of upward film movement, bear this out. Moreover the freezing point lowerings of samples of muck soil taken at different depths from the surface as well as the accumulation of nitrates and other salts at the surface of uncropped soils in larger quantities than in cropped soils show that such is the case. Of course under the latter conditions the lack of accumulation is doubtless due in part to the removal of the nitrates and other substances by the plants. Moreover, the condition is probably less ideal for the formation of such on account of differences in temperature of the soil and also lower water contents. At any rate the salts that appeared on the surface came from relatively short distances below the surface.

Do salts move upward from subsoils to supply the plant? It is considered by some that the movement of salts from the subsoil plays an important role in soil fertility. Considering the results of Leather (3) in India as well as those of Burr (4). Alway (5) and others, which

(3) Leather, J. W. 1908. The Loss of Water from Soil during Dry Weather. In Dep't. of Agr. India. V. 1, No. 6, 116 p., 7 fig.

(4) Burr, W. W. 1914. The Storage and Use of Soil Moisture. Nebr. Agr. Expt. Sta. Research Bul. 5, 88 p.

(5) Alway, F. J. and McDale, G. R. 1917. Relation of the Water Retaining Capacity of a Soil to its Hygroscopic Coefficient. In Journ. Agr. Research V. 9, No. 2, pp. 27-71.

go to show that film movement below the zone of root penetration is slight, and in addition the fact that the force of gravity is operative and also that in the humid region approximately 40 to 50 per cent of the rainfall passes through the soil, it seems logical to conclude that soluble substances carried or formed below the zone of root penetration are of minor importance in crop production; yet investigations now under way may lead to different conclusions.

EFFECT OF PLANT GROWTH ON THE SOLUBLE SALT CONTENT OF SOILS.

Considerable interest has been manifested in the ability of plants to lower the concentration of the soil solution. It was found by Lyon and Bizzell (6) that the nitrate content of the soil under different crops growing on similar soil was quite variable, some crops apparently having the power to stimulate nitrate production while others exerted an inhibitive effect. Much work has also been done by various investigators on the water extract of soils under different conditions of cropping and tillage. Recently, Hoagland (7) showed that under controlled conditions the concentration of the soil solution varies at different periods of the year and is materially affected by plant growth. So far as the writers are aware, however, no data have been published showing whether or not the total concentration of the soil solution as it occurs in field soils is affected by the growth of plants. We have made studies of the effect of plant growth upon the concentration of the soil solution in the soil.

A. CULTURE STUDIES.

In the first series of experiments corn was grown in test tubes containing about 50 grams of soil. When the plants were well-rooted the kernels were removed so as to make the plants dependent upon the mineral nutrients in the soil as soon as possible. After twenty days the plants were removed, the soil screened to free it of roots, and after air drying, made up to a definite water content and the freezing point determined in the usual manner.

The freezing point lowerings and corresponding parts per million of soluble salts, as calculated by the formula derived by Bouyoucos (8) of both the cropped and uncropped soils are shown in table 19.

TABLE 19.—EFFECT OF PLANT GROWTH ON THE CONCENTRATION OF THE SOIL SOLUTION. DURATION OF GROWTH 20 DAYS.

Soil used.	Uncropped soil.		Cropped soil.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Medium sand	.012	300	.005	125
Clyde sandy loam	.022	550	.002	50

(6) Lyon, T. L., and Bizzell, J. A. 1913. Some Relations of Certain Higher Plant to the Formation of Nitrates in Soils, Mem. No. 1, Cornell Uni. Agr. Expt. Sta.
(7) Hoagland, G. R. 1918. The Freezing Point Method as an Index of Variations in the Soil Solution Due to Season and Crop Growth. Journ. Agr. Research, V. XII, No. 6, pp. 369-395
(8) Bouyoucos, G. J. and McCool, M. M. 1916. Further Studies on the Freezing Point Lowering of Soils. Mich. Agr. Expt. Sta. Tech. Bul. 24, 51 p.

The growing plants reduced the salt content of the soil solution in medium sand from 300 to 125 parts per million and in the sandy loam from 550 to 50 parts per million.

These results indicate that the soluble salt content of the soil may be greatly reduced under very intensive cropping.

In order to obtain additional information on this question larger containers were employed. Barley and corn were grown in pots containing three kilograms of soil, the concentration of the soil solution being determined at different stages of their growth. The results derived from this series are set forth in table 20.

TABLE 20.—EFFECT OF PLANT GROWTH ON THE SOLUBLE SALT CONTENT OF SOILS.

	Uncropped soil.		Barley.				Corn.			
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Decrease in depression.	Decrease in parts per million.	Freezing point depression.	Parts per million.	Decrease in depression.	Decrease in parts per million.
Six weeks period.										
Medium sand.....	.012	300	.003	75	.009	225	......	......	......	......
Sandy loam.......	.030	750	.010	250	.020	500	......	......	......	......
Nine weeks period:										
Medium sand.....	.012	300	.002	50	.010	250	.004	100	.008	200
Sandy loam.......	.030	750	.007	175	.023	175	.005	125	.025	625
Twelve weeks period:										
Medium sand.....	.012	300	.000	......	.012	300	.001	25	.011	275
Sandy loam.......	.030	750	.004	100	.026	650	.002	50	.028	700

These data show that in six weeks barley reduced the soluble salt content of medium sand from 300 parts per million to 75 parts and of sandy loam from 750 parts per million to 250 parts. These are very substantial decreases.

After nine weeks the concentration of the soil solution was equally low and after twelve weeks all soluble materials as measured by the freezing point method had been removed from the sand and that in the sandy loam was reduced to 100 parts per million. The results with corn agree perfectly with those obtained with barley.

Another series was run in containers holding approximately 8 kilograms of soil. In order to overcome the effect of salt movement and other factors which tend to an uneven distribution of soluble material in soils, sufficient water was added to make a thick cream and the soil stirred thoroughly. Samples were then withdrawn by means of a spoon. The data obtained are presented in table 21.

TABLE 21.—EFFECT OF PLANT GROWTH ON THE SOLUBLE SALT CONTENT OF SOILS.

Soil type.	At time of planting.		Uncropped soil.		Barley 115 days.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami very fine sandy loan	.012	300	.020	500	.003	75
Clyde silt loam	.004	100	.016	400	.005	125
Clyde clay loam	.013	325	.030	750	.015	375
Clyde sandy loam	.012	300	.023	575	.010	250
Miami sand	.013	325	.044	1,100	.011	275
Miami silt loam	.006	150	.021	525	.015	375
Muck	.005	125	.013	325	.012	300

It seems justifiable to conclude that under the condition of these experiments, that is relatively small volumes of soil, the soluble salt content of soil may be largely utilized by the plants thus reducing the concentration of the soil solution to a minimum. Whether this phenomenon occurs in the field where the quantity of soil exposed to the action of the plant roots is very large, is more doubtful.

B. FIELD STUDIES.

To throw some light upon this question several classes of soil were sampled under different crops. For comparison small areas were scraped free of vegetation early in the spring and maintained so throughout the season, both virgin and adjacent field soils being included. On June 13th samples were taken of the surface ¼ inch and of the soil immediately below to depths of six and twelve inches, respectively. Contamination of the lower sections was prevented by inserting a metal tube to the depth of six inches and taking the sample through it. The samples were taken directly to the laboratory, spread out in a thin layer, allowed to become air dry, made up to a uniform water content and the freezing point lowerings determined in the usual manner.

The results are presented in table 22.

TABLE 22.—FREEZING POINT DEPRESSIONS OF DIFFERENT SECTIONS OF VARIOUS SOILS UNDER DIFFERENT CONDITIONS. SAMPLES TAKEN JUNE 13, 1918.

Description of soil.	Section of soil sampled.					
	¼ in.		¼ to 6 in.		6 to 12 in.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand:						
Virgin soil with grass removed	.023	575	.004	100	.001	25
Virgin soil (sod)	......	......	.006	150	.002	50
Growing timothy and clover	......	......	.002	50	.002	50
Growing barley (fully headed)	.005	125	.002	50	.004	100
Growing oats, jointing stage	.002	50	.002	50	.000	......
Cultivated soil with crops removed	.043	1,075	.001	25	.000	......
Miami sandy loam:						
Virgin soil with grass removed	.028	700	.005	125	.004	100
Virgin soil (sod)	......	......	.002	50	.000	......
Growing rye (fully headed)	.015	375	.008	200	.002	50
Cultivated with crop removed	.255	6,375	.005	125	.003	75
Miami silt loam:						
Virgin soil with grass removed	.018	450	.006	150	.007	175
Virgin soil (sod)	......	......	.003	75	.005	125
Growing alsike (in full bloom)	.011	275	.006	150	.004	100
Cultivated with crop removed	.041	1,025	.008	200	.014	350
Miami very fine sandy loam:						
Virgin soil with grass removed	.012	300	.005	125	.007	175
Virgin soil (sod)	......	......	.012	300	.008	200
Growing oats (jointing stage)	.004	100	.007	175	.002	50
Growing alsike and timothy	.010	250	.008	200	.006	150
Cultivated with crop removed	.101	2,525	.015	375	.010	250
Clyde sandy loam:						
Virgin soil with grass removed	.023	575	.009	225	.011	275
Virgin soil (sod)	......	......	.011	275	.010	250
Cultivated with crop removed	.023	575	......	......	......	......
Clyde silt loam:						
Virgin soil with grass removed	.030	750	.008	200	.013	325
Virgin soil (sod)	......	......	.010	250	.005	125
Growing oats, 15 inches high	.024	600	.008	200	.015	375
Growing clover (in full bloom)	.020	500	.002	50	.013	325
Cultivated with crop removed	.015	375	.001	25	.005	125
Miami silt loam:						
Virgin soil with grass removed	.015	375	.010	250	.010	250
Virgin soil (sod)	......	......	.006	150	.012	300
Growing alsike, full bloom	.007	175	.004	100	.010	250
Cultivated with crop removed	.014	350	.006	150	.002	50

The salt content of the quarter-inch section varied markedly. Where there was no vegetation a considerable concentration of salts was found in this layer, while where vegetation was permitted to grow with few exceptions no such accumulation occurred. Apparently some of the soluble material in the lower section of the uncropped areas moved upward and was concentrated at the surface as was expected from results of experiments reported earlier in this bulletin. It is possible, however, that this accumulation was due in part to the rapid formation of soluble material in this layer and not wholly to its concentration from other sections of soil. The lack of accumulation on the surface of the cropped areas may be explained by the utilization of the soil moisture to such an extent that there was little capillary movement to the surface, which according to data presented previously would greatly reduce the movement of salts. Furthermore, the removal of some of the soluble material by the growing plants is to be considered.

At this season there were no consistent differences between the soluble salt content of the lower sections taken from cropped and uncropped soils, respectively. Moreover, the freezing point lowerings, in general, were low.

Several cropped and uncropped soils were sampled on August 5 and September 3, respectively, and the soluble salt content determined as usual. It is unfortunate that the surface layers or quarter-inch sections were discarded inasmuch as the rainfall had been small ten days previous to sampling, according to the data given in table 34. A study of the results obtained which are given in table 23 leads to the conclusion that

TABLE 23.—EFFECT OF PLANT GROWTH ON THE CONCENTRATION OF THE SOIL SOLUTION.

Soil types and crops grown.	August 5.				September 3.			
	0–6 in.		6–12 in.		0–6 in.		6–1	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand:								
Virgin, grass removed	.005	125	.001	25	.001	25	.002	50
Virgin, grass	.006	150	.004	100	.007	175	.002	50
Hay	.005	125	.004	100	.007	175	.004	100
Oats	.003	75	.003	75	.006	150	.004	100
Crop removed	.006	150	.006	150	...	...	...	...
Miami sandy loam:								
Virgin, grass removed	.002	50	.010	250	.008	200	.002	50
Virgin, grass	.002	50	.002	50	.005	125	.004	100
Wheat	.001	25	.000	...	.002	50	.002	50
Rye	.006	150	.004	100	.009	125	.005	125
Hay	...	...	...	...	.001	25	.002	50
Crop removed	.033	825	.019	475	.031	775	.004	100
Miami silt loam:								
Virgin, grass removed	.010	250	.005	125	.022	550	.006	150
Virgin, grass	*.012*	*300*	*.003*	*75*	*.007*	*175*	*.005*	*125*
Alsike	.002	50	.001	25	.009	225	.008	200
Corn	.019	475	.007	175	.014	350	.008	200
Crop removed	.014	350	.016	400	.010	250	.010	250
Miami, very fine sany loam:								
Virgin, grass removed	.009	225	.010	250	.006	150	.002	50
Virgin, grass	.002	300	.006	150	.004	100	.002	50
Hay	.009	225	.005	125	.005	125	.006	150
Oats	.003	75	.010	250	.006	150	.006	150
Crop removed	.011	275	.012	300	.008	200	.008	200
Clyde sandy loam:								
Virgin, grass removed	.007	175	.005	125	.020	500	.019	475
Virgin, grass	.015	375	.003	75	.007	175	.008	200
Beans	.013	325	.009	225	.012	300	.005	125
Crop removed	.015	375	.004	100	.....	.....	.....	.....
Muck:								
Virgin, grass removed	.023	575	.020	500	.023	575	.018	450
Virgin grass	.013	325	.012	300	.013	325	.011	275
Corn	.020	500	.014	350	.030	750	.022	550
Crop removed	.026	650	.015	375	.044	1,100	.027	675
Clyde silt loam:								
Virgin, grass removed	.037	925	.012	300	.020	500	.008	200
Virgin, grass	.011	275	.011	275	.015	375	.009	225
Red clover	.015	375	.010	250	.009	225	.008	200
Weeds	.009	225	.009	225	.013	325	.011	275
Oats	.007	175	.007	175	.003	75	.004	100
Crop removed	.013	325	.004	100	.009	225	.007	175
Miami silt loam:								
Virgin, grass removed	.008	200	.008	200	.007	175	.006	150
Virgin, grass	.005	125	.000	000	.006	150	.005	25
Weeds	.002	50	.002	50	.....	.....	.....	.....
Crop removed	.005	150	.010	250	.....	.....	.....	.....

the small grains and grasses retarded accumulation of soluble substances in the soil solution in the field soils, although not to such a marked degree as occurred in the cultures. On the other hand, the cultivated crops, corn and beans did not so markedly affect the concentration of the soil solution in the soil. The study of the effect of plant growth on the concentration of the soil is being continued. In the studies several crops are being grown on the various soil classes under different rates of seeding and other conditions.

THE EFFECT OF DIFFERENT CONDITIONS OF A. MOISTURE AND B. TEMPERATURE ON THE RATE OF FORMATION OF SOLUBLE SALTS IN CROPPED AND VIRGIN SOILS.

The differences in productivity between virgin and long cultivated soils has been the subject of much investigation. Chemical analyses have shown in some cases differences in the total as well as the easily soluble mineral nutrients and difference in the organic matter content are some times quite marked. It is admitted, however, that no method yet devised furnishes a consistent measure of the productivity of soils.

Many phases of the factors that effect the solubility of soil constituents have been investigated by Bouyoucos, the results of which appear in another publication.

The idea suggested itself to the writers that possibly there is some difference in the rate of formation of soluble constituents in cropped and virgin soils. In consequence experiments were undertaken to measure the variations in the concentration of the soil solutions of such soils under different conditions of moisture and temperature.

For use in these experiments samples of soils in the vicinity of the College were collected on the 22nd of March. An effort was made to obtain soils which had been cropped for a long period of years with little or no addition of manure or other fertilizing material. A sample of the virgin soil from a line fence was also collected. The samples represent the first six inches of soil. Similar samples were taken May 17th in Lenawee county from soils whose productivity had been greatly decreased.

A. MOISTURE.

High Water Content. For these investigations 20 gram samples of the soils from Ingham county were weighed into ordinary freezing point tubes and 20 c.c. of distilled water added. After one hour the freezing point depressions were determined with a Beckmann thermometer in the usual manner. The tubes were then stoppered and stored in a constant temperature chamber at 25°C. Weekly the contents of the tubes were thoroughly agitated by stirring and shaking and the tubes allowed to stand unstoppered for a short time in order to permit the escape of carbon dioxide which might have been formed and which if allowed to remain might affect the freezing point depression.

The freezing point lowerings of the soil solution and the calculated parts per million of soluble salts after ten and thirty-day periods are shown in table 24.

TABLE 24.—EFFECT OF HIGH MOISTURE CONTENT ON THE RATE OF FORMATION OF SOLUBLE SALTS IN VARIOUS SOILS.

INGHAM COUNTY SOILS.

Description of sample.	High water content.									
	Original.		After 10 days.				After 30 days.			
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.
Miami sand, cultivated	.008	200	.012	300	.004	100	.011	275	.003	75
Miami sand, virgin	.007	175	.017	425	.010	250	.020	500	.013	325
Miami silt loam, cultivated	.007	175	.021	525	.014	350	.035	875	.028	700
Miami silt loam, virgin	.008	200	.036	900	.028	700	.034	850	.026	650
Miami very fine sandy loam, cultivated	.005	125	.016	400	.011	275	.014	350	.009	225
Miami very fine sandy loam, virgin	.007	175	.042	1,050	.035	875	−.030	750	.023	575
Clyde sandy loam, cultivated	.003	75	.037	925	.034	850	−.025	625	.022	550
Clyde sandy loam, virgin	.015	375	.049	1,225	.034	850	−.036	900	.021	525
Miami silt loam, cultivated	.010	250	.028	700	.018	450	.024	600	.014	350
Miami silt loam, virgin	.010	250	.044	1,100	.034	850	.029	725	.019	475

These data show that with the exception of the Clyde sandy loam the virgin soils have a much greater concentration of soil solution after ten days, than do the cropped samples. The increase varies from twice as much in the case of Miami silt loam to three times as much in the case of Miami very fine sandy loam.

At the expiration of the thirty-day period a tendency for the concentrations of the solutions of the cropped and virgin soils to approach each other is noticeable in the case of the samples of Miami silt loam. This is brought about in one case by a further increase of the soluble salts in the cultivated soil and in the other case by a decrease in the salt content of the virgin sample. There is still quite a distinct excess of soluble material in the virgin samples of sand and very fine sandy loam over that of the corresponding cropped soils.

In only one case is there a distinct increase in the amount of soluble material present after 30 days over that found after 10 days while in four cases there is an appreciable decrease. This phenomenon is quite interesting and will be referred to later on.

The data presented indicate that while there is a marked tendency for both cropped and virgin soils to show an increase in soluble salt content after standing at the water content used, the solubility of the virgin soils on the whole is greater than is that of the cropped soils.

Medium Water Content. For these experiments 20 grams of soil were placed in freezing point tubes and 10 c.c. of distilled water added. In the case of the heavy soils this amount of water was sufficient to make a thick mud while with the lighter loams and sands water stood over the surface of the soil after settling.

As in the previous series the freezing point lowerings were determined one hour after adding the water and again after standing ten and thirty days, respectively, at a temperature of 25°C. The same precautions were taken to prevent the accumulation of carbon dioxid or other gases.

The following table shows the results obtained with the soils from Ingham county.

TABLE 25.—EFFECT OF MOISTURE CONTENT ON THE RATE OF FORMATION OF SOLUBLE SALTS IN VARIOUS SOILS.

INGHAM COUNTY SOILS.

Description of sample.	Medium water content.									
	Original.		After 10 days.				After 30 days.			
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.
Miami sand, cultivated	.005	125	.021	525	.016	400	.014	350	.009	225
Miami sand, virgin	.007	175	.030	750	.023	575	.022	550	.015	375
Miami silt loam, cultivated	.012	300	.022	550	.010	250	.015	375	.003	75
Miami silt loam, virgin	.014	350	.016	400	.002	50	.012	300	....	....
Miami very fine sandy loam, cultivated	....	....	.024	600	.024	600	.016	400	.016	400
Miami very fine sandy loam, virgin	.010	250	.041	1,025	.031	775	.026	650	.016	400
Clyde sandy loan, cultivated	.012	300	.025	625	.013	325	.009	225	—.003	....
Clyde sandy loam, virgin	.017	425	.016	400	—.001	....	.010	250	—.010	....
Miami silt loam, cultivated	.007	175	.022	550	.015	375	.010	250	.003	75
Miami silt, virgin loam	.012	300	.034	850	.022	550	.035	875	.023	575

The above data show an increase in the concentration of the soil solution after 10 days in all cases except one, namely, the virgin sample of Clyde sandy loam, which remained practically constant. In three cases there was a greater increase in the soluble salt content of the virgin samples than of the cropped, while in two instances the increase in concentration of the soil solution of the cropped soils was greater than that of the virgin.

After 30 days only two samples showed a greater increase in the salt content of the virgin soils than of the cropped. In one case both cropped and virgin samples decreased in soluble salt content and in one case the increase was the same.

It is interesting to note that the tendency for the soluble salt content to decrease between the 10-day and 30-day periods which was observed with the high water content used in the preceding experiment was much magnified in this series.

The results obtained from Lenawee county soils with medium water content are given in table 26.

TABLE 26.—EFFECT OF MOISTURE CONTENT ON THE RATE OF FORMATION OF SOLUBLE SALTS IN VARIOUS SOILS.

LENAWEE COUNTY SOILS.

Description of sample.	Medium water content.									
	Original.		After 10 days.				After 30 days.			
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.
Silt loam, cultivated	.017	425	.007	175	−.010	......	......	......	......	......
Silt loam, virgin	.016	400	.034	850	.018	450	.059	1,475	.043	1,075
Silt loam, cultivated	.014	350	.019	475	.005	125	.035	875	.021	525
Silt loam, virgin	.012	300	.024	600	.012	300	.058	1,450	.046	1,150
Medium sand, cultivated	.006	150	.006	150	......	......	.027	675	.021	525
Medium sand, virgin	.017	425	.039	975	.022	550	.074	1,850	.057	1,425
Clay loam, cultivated	.023	575	.024	600	.001	25	.015	375	.008	200
Clay loam, virgin	.015	375	.017	425	.002	50	.039	975	.024	600
Sandy loam, cultivated	.009	225	.012	300	.003	75	.034	850	.025	625
Sandy loam, virgin	.016	400	.037	925	.021	525	.056	1,400	.040	1,000
Medium sand, cultivated	.007	175	.002	50	−.005	−125	......	......	......	......
Medium sand, virgin	.006	150	.012	300	.006	150	.022	550	.016	400
Silt loam, cultivated	.016	400	.033	825	.017	425	.050	1,250	.034	850
Silt loam, virgin	.021	525	.038	950	.017	425	.055	1,350	.034	850

The Lenawee county soils showed no appreciable increase in the concentration of the soil solution after 10 days in five instances. In two cases there was a slight decrease in the concentration of the soil solution. In five soils the virgin samples showed a decidedly greater increase in the soluble salt content than the cropped samples.

At the end of the thirty-day period these soils exhibited a decided difference in behavior from the Ingham county soils under the same conditions. In every case but one there was a marked increase in the soluble salt content above that present after ten days. This is a very interesting point and further reference will be made to it.

At the end of the second period four soils showed a greater increase in the concentration of the solution of the virgin sample than in that of the cropped. In one soil there was no difference and in two cases the cropped samples were lost so comparisons could not be made.

A summary of the results with the Lenawee county soils brings out that there is a tendency for virgin soils to go into solution to a greater extent than the cropped. This agrees with the results from the Ingham county soils at high water content but is somewhat at variance with the results obtained when a medium water content was used.

Optimum Water Content. In order to simulate field conditions more nearly it was considered advisable to carry on a series of experiments in which the soils were maintained at a moisture content similar to that found under natural conditions.

For this investigation samples of soil from Lenawee county were used. They were brought to a laboratory as quickly as possible, screened through a coarse screen and thoroughly mixed. When not sufficiently moist distilled water was added to bring them to optimum moisture content. Two hundred gram samples were weighed into sterile tumblers and incubated at 25°C. To determine the freezing point depression sufficient distilled water was added to make a thick cream and the soil stirred thoroughly to insure uniformity. Samples were removed with a spoon to a freezing point tube and the determinations made with the Beckmann thermometer, as usual.

In the table below are found the freezing point depressions and the calculated parts per million of soluble salts present at the beginning of the experiment and after 16 and 42-day periods.

TABLE 27.—EFFECT OF MOISTURE CONTENT ON THE RATE OF FORMATION OF SOLUBLE SALTS IN VARIOUS SOILS.

LENAWEE COUNTY SOILS.

Description of sample.	Optimum water content.									
	Original.		After 16 days.				After 42 days.			
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.	Freezing point depression.	Parts per million.	Increase in depression.	Increase in parts per million.
Silt loam, cultivated	.002	50	.023	575	.021	525	.015	375	.013	325
Silt loam, virgin	.004	100	.025	625	.021	525	.018	450	.014	350
Silt loam, cultivated	.008	200	.026	650	.018	450	.021	525	.013	325
Silt loam, virgin	.005	125	.022	550	.017	425	.010	250	.005	155
Medium sand, cultivated	.010	250	.022	550	.012	300	.012	300	.002	50
Medium sand, virgin	.011	275	.035	875	.024	600	.033	825	.022	550
Clay loam, cultivated	.018	450	.020	500	.002	50	.019	475	.001	25
Clay loam, virgin	.011	275	.029	725	.018	450	.005	125	....	....
Sandy loam, cultivated	.006	150	.021	525	.015	375	.009	225	.003	75
Sandy loam, virgin	.008	200	.024	600	.016	400	.015	375	.007	175
Medium sand, cultivated	.000	.000	.008	200	.008	200	.003	75	.003	75
Medium sand, virgin	.003	75	.017	425	.014	350	.018	450	.015	375
Silt loam, cultivated	.023	575	.032	800	.009	225	.022	550	.001	25
Salt loam, virgin	.008	200	.028	700	.020	....	.027	675	.019	475

All the samples showed a marked increase in soluble salt content after incubating sixteen days, except a silt loam taken from a poorly drained area.

In four of the seven soils tested there was an appreciably greater increase in the concentration of the soil solution of the virgin samples than of the cropped. The cropped and virgin samples of the other three soils seem to have increased at approximately the same rate.

After forty-two days incubation at 25° C, a distinct decrease in the soluble salt content of several samples was observed. This is in accord with the results obtained with the Ingham county soils at high and medium water content, but somewhat at variance with the data for the Lenawee county soils at medium water content. To what this decrease in soluble salts is due is not made evident. It may be in some cases due to the utilization of the soluble material by organisms or it may be due to a readsorption of the salts by the soil or to the formation of less soluble substances.

At the end of this period the virgin samples of four of the soils were found to have larger amounts of soluble salts present than the corresponding cropped samples. In one case the cropped sample attained a higher concentration than the virgin and in the remaining soils practically no difference was evidenced. In conclusion it may be stated that on the whole there is a difference in the rate of solubility of cropped and virgin soils. In some cases the difference is slight and even the reverse condition may exist, but apparently a decrease in the rate of formation of soluble substances is one of the changes which soils usually undergo as a result of long continued cropping without the addition of fertilizing material.

It must be noted, however, that the date of sampling of soils probably has a great deal of influence upon the reaction of the soil under different conditions of moisture and temperature. In other words the organisms in the soil and also the salt content are factors to be reckoned with. A sample of soil taken from the field in March may react differently from another sample taken later on in the growing season. In fact our preliminary studies point strongly in this direction.

B. TEMPERATURE.

The soils used in the investigation were those collected in Ingham and Lenawee counties. Twenty grams of the air dry soil were treated with ten cubic centimeters of distilled water in a freezing point tube. One series was stored in a constant temperature chamber at 25° C. These samples were agitated every week to remove gas as before described. The second series of tubes were kept in ice water. These samples were also aerated occasionally to allow the escape of gaseous material.

In table 28 are given the freezing point depressions of the Ingham county soil solutions and also the soluble salt content in parts per million after periods of ten and thirty days at the respective temperatures.

TABLE 28.—EFFECT OF TEMPERATURE ON THE RATE OF FORMATION OF SOLUBLE SALTS IN VARIOUS SOILS.

INGHAM COUNTY SOILS.

Description of sample.	Original.		After 10 days.				After 30 days.			
			25° C.		Low temperature.		25° C.		Low temperature.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand, cultivated	.005	125	.021	525	.020	500	.014	350	.00[illegible]	175
Miami sand, virgin	.007	175	.030	750	.018	450	.022	550	.012	300
Miami sandy loam, cultivated	.007	175	.034	850	.016	400	.024	600	.012	300
Miami sandy loam, virgin	.009	225	.047	1,170	.021	525	.025	625	.013	325
Clyde clay loam, cultivated	.017	425	.033	825	.025	625	.....	.....	.012	300
Clyde clay loam, virgin	.015	375	.026	650	.....	.....	.019	475	.....	.....
Miami silt loam, cultivated	.012	300	.022	550	.013	325	.015	375	.006	150
Miami silt loam, virgin	.014	350	.016	400	.013	325	.012	300	.018	450
Miami very fine sandy loam, cultivated	.000	000	.024	600	.016	400	.016	400	.016	400
Miami very fine sandy loam, virgin	.010	250	.041	1,025	.022	550	.026	650	.019	475
Clyde sandy loam, cultivated	.012	300	.025	625	.019	475	.009	225	.018	450
Clyde sandy loam, virgin	.017	425	.016	400	.011	275	.010	250	.013	325
Muck, cultivated	.016	400	.056	1,400	.016	400	.042	1,500	.027	675
Muck, virgin	.011	275	.076	1,900	.017	425	.012	300	.028	700
Clyde silt loam, cultivated	.015	375	.033	825	.025	625	.009	225	.004	100
Clyde silt loam, virgin	.016	400	.....	.....	.015	325	.....	.....	.013	325
Miami silt loam, cultivated	.007	175	.022	550	.017	425	.010	250	.004	100
Miami silt loam, virgin	.012	300	.034	850	.018	450	.035	875	.013	325

Considering the results at the conclusion of the ten-day period it is seen that with the exception of two samples all the soils stored at 25°C showed an appreciable increase in the concentration of the solution. Of the samples maintained at the low temperature several failed to show an appreciable increase in the soluble salt content. It is noteworthy that the increases in concentration of the solution of soils kept in ice are much smaller than those of the samples maintained at 25°C.

After thirty days a general tendency for the concentration of the soil solution to be less was observed in the samples stored at both temperatures. There are more exceptions to this in the series maintained at the low than at the higher temperature. The samples held at the low temperature on the whole showed a lower average concentration of the soil solution than those placed in the 25°C chamber, but due to the failure of a number of the samples maintained at the low temperature to decrease in soluble salt content between the ten-day and thirty-day periods, there are a number of cases where this is not true.

The results obtained from studies of the Lenawee county soils at the close of the thirty-day period are to be found in table 29.

TABLE 29.—EFFECT OF TEMPERATURE ON THE RATE OF SOLUBILITY OF VARIOUS SOILS.

LENAWEE COUNTY SOILS.

Description of sample.	Original.		After 30 days.			
			25°C.		Low temperature.	
	Depression.	Parts per million.	Depression.	Parts per million.	Depression.	Parts per million.
Silt loam, cultivated	.017	425	.....	.....	.014	350
Silt loam, virgin	.016	400	.059	1,475	.....	.....
Silt loam, cultivated	.014	350	.035	875	.012	300
Silt loam, virgin	.012	300	.058	1,450	.013	325
Medium sand, cultivated	.006	150	.027	675	.....	.....
Medium sand, virgin	.017	425	.074	1,850	.019	475
Clay loam, cultivated	.023	575	.015	375	.....	.....
Clay loam, virgin	.015	375	.039	975	.020	500
Sandy loam, cultivated	.009	225	.034	850	.008	200
Sandy loam, virgin	.016	400	.056	1,400	.027	675
Medium sand, cultivated	.007	175	.....	.....	.006	150
Medium sand, virgin	.006	150	.022	550	.021	525
Silt loam, cultivated	.016	400	.050	1,250	.....	.....
Silt loam, virgin	.021	525	.055	1,350	.017	425

After thirty days with one exception the samples stored at 25°C showed considerable increases in soluble salt content over that which they contained at the beginning of the experiment, while the difference in the freezing point lowerings of the soils maintained at this lower temperature did not differ markedly from the originals.

THE SOLUBLE CONTENT OF UNCROPPED FIELD SOILS AT DIFFERENT SEASONS OF THE YEAR.

It was pointed out in an earlier part of this paper that temperature and moisture content have an appreciable effect on the solubility of the soil constituents. In view of this it may be expected that the soluble salt content of field soils will vary somewhat with the seasonable variations of climate. In order to obtain information concerning the relative magnitude of such variations, if they occur, samples were obtained from several soil classes at different periods during the growing season. Both the virgin soils and soils from adjacent fields were sampled.

To obviate the effect of plant growth small areas were kept free from vegetation and the samples taken from these areas. Owing to a misunderstanding the surface quarter inch of soil was removed before sampling and then sections taken to a depth of six and twelve inches, respectively. The results thus far obtained are presented in tables 30, 31, 32, 33, and the diagramatic presentation of the data is set forth in the accompanying graphs.

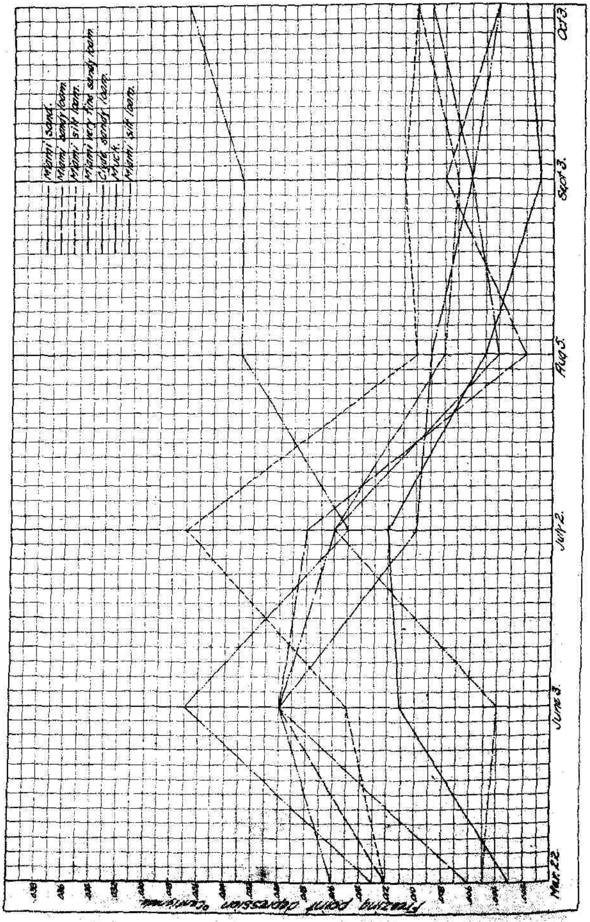


Plate 1.—Freezing point depressions of virgin soils at different periods of the year.

TABLE 30.—FREEZING POINT DEPRESSION OF VIRGIN SOILS AT DIFFERENT PERIODS OF THE YEAR AND THE CORRESPONDING PARTS PER MILLION OF SOLUBLE MATERIAL.

Soil type.	March 22.		June 3.		July 2.		August 5.		September 3.		October 3.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand	.003	75	.011	275	.012	300	.005	125	.001	25	.002	50
Miami sandy loam	.012	300	.020	500	.018	450	.002	50	.008	200	.004	100
Miami silt loam	.012	300	.015	325	.027	675	.010	250	.011	275	.010	250
Miami very fine sandy loam	.006	150	.020	400	.010	250	.009	225	.006	150	.009	225
Clyde sandy loam	.016	400	.020	400	.016	400	.004	100	.006	150	.004	100
Muck	.013	325	.027	675	.015	325	.023	575	.023	575	.027	675
Miami silt loam	.005	125	.004	100	.016	400	.008	200	.007	175	.010	250

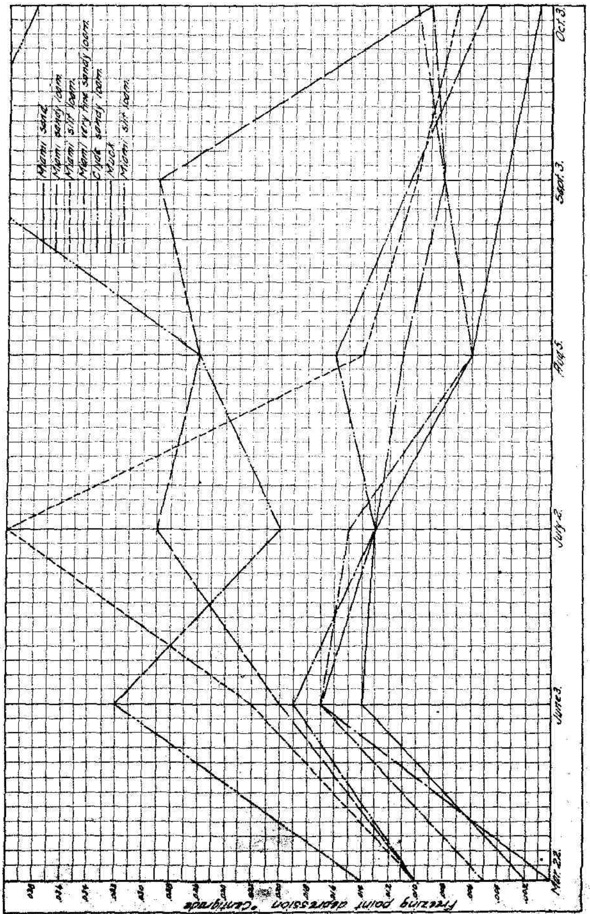


Plate 2.—Freezing point depressions of soils from previously cropped areas, at different periods of the year.

TABLE 31.—FREEZING POINT DEPRESSIONS OF SOILS FROM PREVIOUSLY CROPPED AREAS AT DIFFERENT PERIODS OF THE YEAR AND THE CORRESPONDING PARTS PER MILLION OF SOLUBLE MATERIAL.

Soil type.	March 22.		June 3.		July 2.		August 5.		September 3.		October 3.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand	.002	50	.014	350	.013	325	.006	150	....	....	.001	25
Miami sandy loam	.010	250	.020	500	.029	725	.026	650	.029	725	.009	225
Miami silt loam	.010	250	.022	550	.040	1,000	.014	350	.010	250	.007	175
Miami very fine sandy loam	.000	000	.017	425	.013	325	.011	275	.008	200	.009	225
Clyde sandy loam	.010	250	.019	475	.013	325	.016	400	....	....	.005	125
Muck	.014	350	.032	800	.020	500	.026	650	.044	1.100	.038	950
Miami silt loam	.005	125	.017	425	.015	375	.006	150	....	....	.010	250

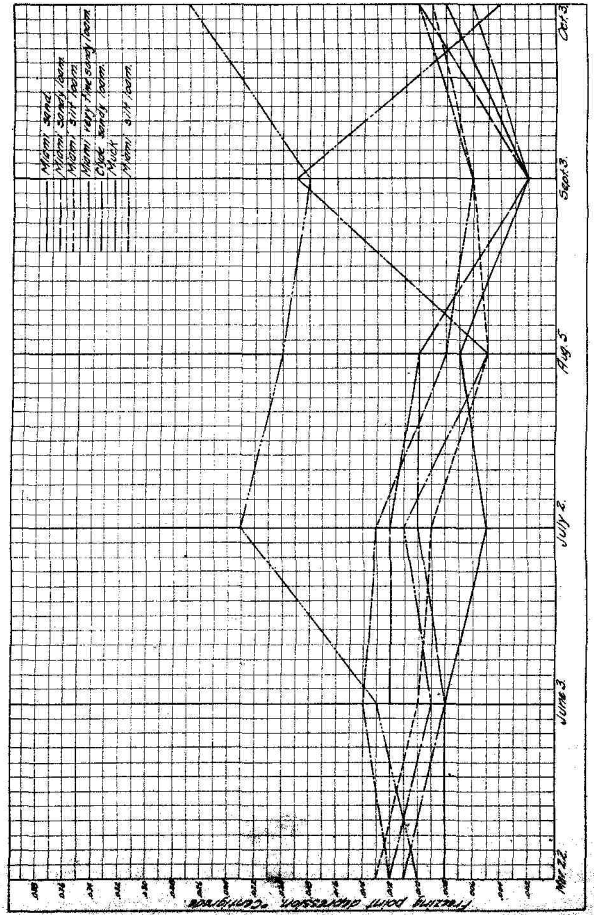


Plate 3.—Freezing point depressions of virgin subsoils at different periods of the year

TABLE 32.—FREEZING POINT DEPRESSIONS OF VIRGIN SUBSOILS AT DIFFERENT PERIODS OF THE YEAR AND THE CORRESPONDING PARTS PER MILLION OF SOLUBLE MATERIAL.

Soil type.	March 22.		June 3.		July 2.		August 5.		September 3.		October 3.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand	.008	200	.008	200	.005	125	.007	175	.002	50	.008	200
Miami sandy loam	....	....	.012	300	.012	300	.010	250	.002	50	.012	300
Miami silt loam	.013	325	.010	250	.009	225	.005	125	.006	150	.009	225
Miami very fine sandy loam	.011	275	.008	200	.010	250	.010	250	.002	50	.006	150
Clyde sandy loam	.012	300	.009	225	.011	275	.005	125	.019	475	.004	100
Muck	.010	250	.013	325	.023	575	.020	500	.018	450	.027	675
Miami silt loam	.012	300	.014	100	.013	325	.008	200	.006	150	.010	250

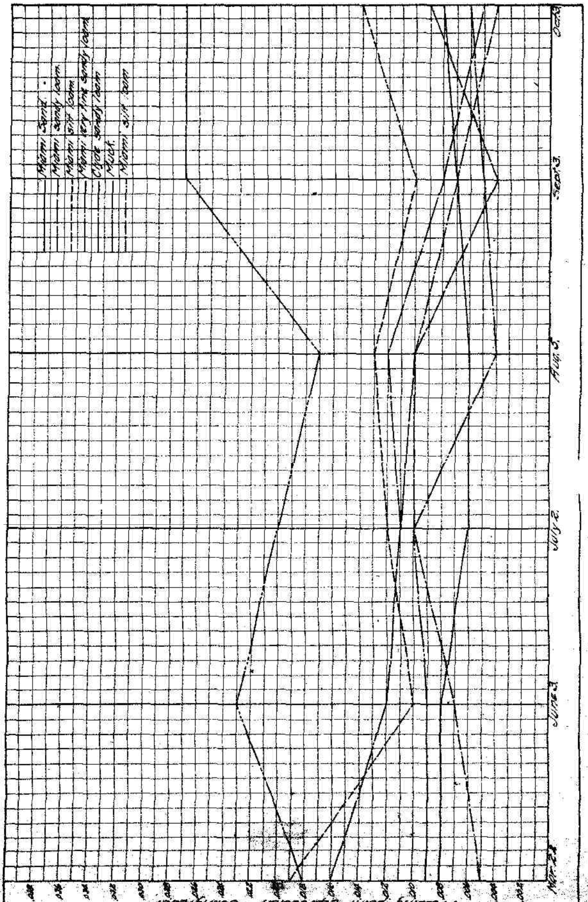


Plate 4.—Freezing point depression of subsoils from previously cropped areas at different periods of the year.

TABLE 33.—FREEZING POINT DEPRESSION OF SUBSOILS FROM PREVIOUSLY CROPPED AREAS AT DIFFERENT PERIODS OF THE YEAR AND THE CORRESPONDING PARTS PER MILLION OF SOLUBLE MATERIAL.

Soil type.	March 22.		June 3.		July 2.		August 5.		September 3.		October 3.	
	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.	Freezing point depression.	Parts per million.
Miami sand	.008	200	.008	200	.006	150	.006	150	.....	.....	.008	200
Miami sandy loam	.....	.....	.012	300	.011	275	.010	250	.004	100	.009	225
Miami silt loam	.019	475	.010	250	.012	300	.013	325	.010	250	.014	350
Miami very fine sandy loam	.016	400	.012	300	.011	275	.012	300	.008	200	.005	125
Clyde sandy loam	.009	225	.009	225	.010	250	.004	100	.....	.....	.006	150
Muck	.018	450	.023	575	.020	500	.017	425	.027	675	.027	675
Miami silt loam	.005	125	.007	175	.010	250	.010	250	.....	.....	.004	100

As shown by the data the concentration of the soil solution in the soils was found to vary especially in the surface layer. With the exception of the virgin sample of Miami silt loam, there was a larger amount of soluble material present in the surface soil on June 3rd than there was in the early spring. From June 3rd to July 2nd there was more variation in the behavior of the soils, the majority showing a decrease in the concentration of the soil solution while several showed a further increase. During August, September and October the amount of soluble material present in practically all the soils was quite small and showed no great tendency to vary. This tendency for the soil solution to reach a maximum concentration in the early summer, when plant growth is at a maximum is extremely interesting. The behavior of the muck soil was radically different from that of the mineral soils, especially during the latter part of the season, when a decided tendency for the concentration of the soil solution to increase still further was manifested. It is interesting to note that the fluctuations in concentration of the soil solution of the soils previously cultivated were much more marked than those from the virgin areas. This may possibly be due to the distribution of the organic matter to a greater depth thus affording a large zone of action to the soil organisms.

The concentration of the soil solution of the lower layer of the soils studied showed no tendency to increase in June and July. In fact in several cases a slight decrease was noted. During the remainder of the season the variations in the amount of soluble material present were also quite small. There seemed a tendency for a slight decrease in concentration on September 3rd, but the amount of change was almost negligible. Aside from the lack of variation in the concentration of the soil solution in this layer of soil the most interesting point brought out is the small amount of soluble material present during the growing season. The muck soil again is at variance with the mineral soils, it containing much more soluble material and showing somewhat more of a tendency for the amount present to vary.

The results of this study indicate that the changes in concentration of the soil solution of soils free of vegetation and untilled are confined mainly to the surface layer. These changes are more pronounced during the period from March twenty-second until July second, although the precipitation data in table 34 should be considered in this connection. Moreover, the soils which had been under cultivation a number of years showed a greater activity in this respect than the corresponding virgin soils. These studies together with additional ones are being continued.

TABLE 34.—RAINFALL AT EAST LANSING.

	March.	April.	May.	June.	July.	August.	Sept.	Oct.
1	0	.08	0	0	0	0	0	.10
2	0	.22	0	0	.04	0	T	.04
3	0	.04	T	0	0	0	0	0
4	.11	0	0	0	0	.04	1.42	0
5	0	0	.21	T	T	0	0	0.01
6	T	.02	.15	.13	0	0	0	T
7	0	.02	.22	0	0	0	.25	0
8	0	T	0	0	0	.04	0	0.05
9	.66	0	.25	.01	0	T	0	0.15
10	.01	0	.16	.03	.21	0	0	0
11	0	.01	0	0	.28	.16	.39	0.06
12	0	0	.93	0	0	T	.26	0.01
13	1.49	0	T	T	0	0	0	.0
14	.64	0	0	.23	0	0	.04	0
15	T	0	0	0	T	0	.10	0
16	0	.05	0	T	.06	.03	0.18	0
17	0	.54	T	0	0	0	0	0
18	0	.04	0	0	0	0	0.03	0
19	0	0	.04	0	0	0	0.01	0.35
20	0	.02	.01	0	0	0	0.02	0.33
21	T	.16	0	.17	0	.11	T	0
22	0	.04	.13	0	T	0	0	0
23	0	.08	0	0	T	.25	0	0.44
24	0	0	.08	.01	0	0	0.05	0.69
25	0	0	.41	.02	T	0	0.12	0.04
26	T	.11	.08	0	1.36	0	0	T
27	0	.01	.05	.32	T	0	0	0.84
28	0	.27	.02	.02	0	.42	0	T
29	0	.06	.08	0	.01	0	0.01	T
30	0	.20	.07	1.13	0	T	0	0
31	.67	......	T	......	0	.39	......	0.10
Total	3.58	1.97	2.89	2.07	1.96	1.44	2.88	3.21

CONCLUSION.

The translocation of salts in the soil is due mainly to water movements. When large quantities of salt are present there is a movement to areas of lower concentration even when water movements are prevented. Higher water contents of the soil aid this movement.

Since the soluble salt content of field soils is relatively low according to the data presented, it is probable that plants are supplied with food elements by diffusion from local areas around the roots only.

The accumulation of soluble salts on the surface of uncropped areas indicate that when water movements occur in the soil salts are carried along with it. That these movements do not take place to any great depth is evidenced by the results of various investigations showing but little movement of water from the subsoil to the feeding zone of the roots. It seems improbable that any great quantity of soluble material is supplied to the plants from depths below those of root penetration.

The quantity of soluble salts in greenhouse soils may become too great for proper plant development. Moreover, plant growth may be inhibited in muck soils by the accumulation of soluble substances in the upper layers.

The data presented show that plants may materially reduce the soluble salt content of the soil.

As a result of laboratory studies it appears that the constituents of soil which have been cropped for a long period of years go into solution at a somewhat slower rate than do those of the corresponding virgin soils.

The rate of solution of the soils studied is governed to some extent by temperature it being more rapid at 25° C than at temperatures approaching 0° C. Moreover, the moisture content has a marked influence on the rate of solubility of the soil constituents. It is probable that biological activities play an important role in these phenomena.

Usually the concentration of the soil solutions, at all water contents, of the soils tested, were lower at the end of thirty days than after ten days, that it under laboratory conditions. This may be due to reabsorption of the soluble material by the soil, to the utilization of the salts by organization and to the formation of less soluble compounds.

The concentration of the soil solution in the soil is variable. In several soils studied it varied somewhat with the seasons, rainfall, different depths of the soil and with plant growth.

It is probable that the variations in the concentration of the soil solution, in some instances at least, have not been sufficiently considered in biological studies where conclusions have been drawn based upon the results obtained from studies of the water extracts of soils. Moreover, it does not seem possible to determine the fertilizer needs of soils by obtaining water extracts and growing plants therein.

The seasonable variation in the soluble salt content of soils doubtless plays an important role in the results obtained from the use of fertilizers. Additional information concerning the soluble salt content of soils will be presented later.

RATE AND EXTENT OF SOLUBILITY OF SOILS UNDER DIFFERENT TREATMENTS AND CONDITIONS

Technical Bulletin No. 44.

BY GEORGE J. BOUYOUCOS.

INTRODUCTION.

A study of the rate and extent of solubility of soils is obviously of the greatest fundamental importance both from the practical as well as the theoretical standpoint. In this study are involved the important questions (1) of the velocity and amount of soil material going into solution; (2) to what extent the solubility of soils follows the recognized laws of solution such as the mass law, solubility law, etc., (3) if the solubility of soils attains equilibrium and the soil solution becomes saturated and remains constant; (4) the difference in rate and extent of solubility of soils under different treatments and state of fertility, etc.

From the answers to these questions it can then be ascertained (1) the rate at which the soils are able to give up material to the solution for the use of the plants; (2) the rate and amount of material that is likely to be lost through leaching; (3) the velocity at which soils are able to recuperate after a thorough leaching or exhaustion by the growth of plants, etc. All this information is of course of the greatest importance in the study of the fertility of soils.

Although a tremendous amount of work has been done on the quantity of soluble salts in soils, very little work has been performed on the rate and extent of solubility of soils. Indeed, there appears to be on record no extensive, thorough and purposeful investigation upon the problem except a few incidental experiments or indirect observations.

As a result of this insufficient investigation our present knowledge of the subject is very limited, conflicting and confusing.

With the hopes of contributing, if possible, a definite and true solution of the problem an investigation of it was undertaken. In this investigation a new method was applied, namely, the freezing point method. This method appeared and has proved to be very ideal for the purpose. The problem received a thorough study and it is the object of this bulletin to present the results obtained.

The investigation was begun in June, 1917. In February, 1918, or nine months later, there appeared in the Journal of Agricultural Research an article by D. R. Hoagland entitled "The Freezing Point Method as an Index of Variation in the Soil Solution Due to Season and Crop Growth." In this article Hoagland presents one or two experiments which were already independently done by the writers. It will be of interest to state that the results of these respective experiments lead all of us to draw identical conclusions.

The general subject of solubility of soils under different conditions and treatments is being investigated at this laboratory from all different angles. McCool and Millar are making a very detailed and comprehensive study on the salt content and solubility of virgin and cropped soils, using the freezing point method as a means, and in addition the carbon dioxide produced is also being determined, while Spurway is making a chemical analysis of the material that goes into solution in treated and untreated soils upon long standing in contact with water.

METHODS OF PROCEDURE.

The rate and extent of solubility of soils were measured (1) in natural or untreated soils, (2) in soils treated with salts and acids, and (3) in treated and untreated soils at various moisture contents and at different degrees of temperature.

In order to secure a proper and accurate measurement of the rate and extent of solubility the soils, both treated and untreated, were washed until they had a freezing point depression very close to that of distilled water. The advantage and necessity of this procedure are obvious. If the soils were not washed their solution might already be in equilibrium or saturated and consequently no definite and reliable data could be obtained on their rate and extent of solubility.

The natural soils were washed by placing a certain amount of soil, either air-dried or fresh, upon a filter paper in a funnel and washed by the bleaching process until practically all their free-soluble salts were washed away as indicated by the freezing point depression. The washing was usually continued until the depression of the soil was reduced to about .005° C, which is equivalent to about 125 parts of solid matter per million parts of liquid. The amount of water that was necessary to pass through the soil to reduce its salt content to the above amount varied with the soil but it usually ranged from 400 to 800 c.c.

In the case of the treated soils about 50 grams of soil were mixed with 150 c.c. of N/10 salt solution or acid, and the mixture allowed to stand for about 24 hours, with occasional shaking. It was then poured on the filter paper in the funnel and the soil washed until its freezing point depression was reduced to the desired point.

After the soils were washed two procedures were usually followed: In the one procedure a small amount of the washed soil was placed in a glass freezing point tube and enough water was added to it to bring it up to a medium thin mud or to a ratio of 1 of soil to .7 of water. The soil was allowed to remain in the tube, care being taken to prevent loss of water by keeping the tube stoppered, and the freezing point depression of the soil was determined immediately and often thereafter as it was deemed necessary. Usually the determination was made every day the first four or five days and quite often thereafter. Many of the experiments were allowed to continue for four months.

In the second procedure, the remaining washed soil was allowed to lose moisture on the filter paper undisturbed until it reached the optimum moisture content and then it was placed in a glass tumbler, mixed thoroughly, weighed, and from time to time water was added to it to maintain its moisture at the optimum content. At the end of 10, 30 and 60

days a sample was taken from the soil, air-dried, and its freezing point depression determined by using 15 grams of air dry soil with 10 c.c. of water.

In the first procedure it was desired to ascertain the rate and extent of solubility of soils at a rather high moisture content or when there was plenty of free water present, so that when the soil had thoroughly settled in the tube *there would be a thin layer of free water at the top of* the soil column.

In the second procedure it was desired to attain the same object when the moisture content was maintained at the optimum content and thus under more practical conditions.

In a limited number of experiments a third procedure was also followed. In order to study more extensively the effect of the mass law or the relative masses of soil and water upon the solubility of soils 5 grams of soil were placed in the freezing tube and washed several times by decantation. Then to this washed soil was added about 25 c.c. of distilled water so that the ratio of soil to water was about 1 to 5. The rate and extent of solubility of soils at this high water content were measured in the same manner as in the other studies.

The rate and extent of solubility of soils at these various moisture contents were measured at different temperatures. On the whole, only three sets of temperatures were employed (1) below freezing, 20° (room temperature) and 53°C. The results at below freezing were obtained outdoors during the winter months, and those at 53°C in a constant temperature oven.

The soils at the optimum moisture content were kept mostly outdoors. In fact, an attempt was made to simulate as much as possible the practical or field conditions.

The tubes containing the soils *at the high moisture contents* were kept stoppered, but in order to avoid the accumulation of any gases and especially carbon dioxide, they were opened very often and the soils *were stirred and thoroughly aerated.*

The freezing point apparatus employed was practically the same as that used in former investigations and described in previous publications.[1] *It consisted briefly of two parts, a bath and a Beckmann thermometer.* The bath was composed of two earthen-ware jars placed one inside the other and well insulated. Its temperature was maintained at about -2° by means of crushed ice and common salt.

The freezing point lowering was determined by placing the tube containing the soil directly into the cooling mixture and stirred the soil constantly by means of the Beckmann thermometer until the temperature fell to about 1° above the zero point of the thermometer. Then the soil was allowed to remain undisturbed until its temperature fell to about 0.5° below the zero point of the thermometer when the soil was again stirred by means of the thermometer in order to cause solidification to take place. As soon as solidification commenced the tube was at once taken out of the cooling mixture and placed in the air jacket in the same bath. The soil was gently stirred, the thermometer tapped and the freezing point read by means of a lens. By this procedure it took only about ten minutes to make a freezing point determination.

(1) Mich. Agri. Expt. Sta. Fed. Bul. 31, 1916.

EXPERIMENTAL WORK.

Rate and Extent of Solubility of Soils Treated with Single Salt Solutions and then Washed until all their Free Soluble Salts were Eliminated. Ratio of Soil to Water was 1 to .7 and Mixture Maintained at Room Temperature.

From the logical standpoint the investigation on the solubility of natural or untreated soils ought to be considered first, but because of the fact that the investigation on the solubility of treated soils presents many more fundamental and general principles and offers a better basis for general understanding and explaining, it is considered first.

The first study of the solubility of treated soils consisted of measuring the rate and extent of solubility of various soils treated with single salt solutions of tenth normal strength and then washed until all their free soluble salts were eliminated and the washed soils had a freezing point depression almost the same as that of the untreated soils, and very close to that of the distilled water. As a rule the depression was about .010°C or 250 parts per million of solution. In some cases this depression was a little higher. As previously stated the treatment consisted of mixing about 50 grams of soil with 150 c.c. of solution allowing the mixture to stand about 24 hours, with occasional shaking and then washing the soil by the process of leaching. Some of the washed soil was then placed in the freezing point tube, water being added to it to bring it up to the water content of about 1 of soil to .7 of water, in the case of the heavy types of soils, and to about 1 to .5 in the case of the light type of soils, and the freezing point depression determined immediately, once every day during the first four or five days and quite often thereafter, meanwhile the soil being kept at room temperature which average about 20°C.

There were seven different soils employed in this study, one clay, two clay loams, two silt loams, one sandy loam, and one sand. Each one of these soils was treated with ten different salt solutions, namely, $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, KH_2PO_4, $CaH_4(PO_4)_2$ and $NaC_2H_3O_2$. For each treated soil there was always an untreated soil run for a check. In all of the salt solutions the strength was tenth normal.

The results obtained in this study are presented in tables 1 to 7 inclusive. They show the rate and extent of solubility of these treated soils as measured by the freezing point method. For clearness and as an aid to better understanding typical examples of these results are diagramatically represented in figures 1 to 5 inclusive. In these figures some irregularities are noted. These irregularities are due to slight errors in the determination and to the different changes that are taking place in the soil. They are, however, very insignificant in magnitude and of no consequent importance.

TABLE 1.—RATE AND EXTENT OF SOLUBILITY OF WISCONSIN SUPERIOR CLAY TREATED WITH SALTS AND THEN WASHED UNTIL ALL FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	1	2	5	13	29	51	82
	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	010	.016	.018	.020	.024	.025	.027	.030
$NaNO_3$	.017	.020	.025	.042	.052	.071	.072	.072
KNO_3	.014	.018	.020	.030	.035	.045	.049	.052
KCl	.017	.025	.032	.035	.040	.044	.050	.050
K_2SO_4	.012	.027	.030	.032	.040	.045	.045	.045
$(NH_4)_2SO_4$	.016	.040	.048	.053	.060	.085	.083	.074
$MgSO_4$	.010	.017	.019	.021	.025	.030	.031	.035
$CaH_4(PO_4)_2$	.010	.018	.020	.024	.028	.030	.030	.035
KH_2PO_4	.011	.019	.020	.025	.030	.030	.035	.037
$NaC_2H_3O_2$	.022	.037	.042	.050	.062	.082	.093	.090
Check	.002	.005	.010	.015	.017	.020	.022	.023

TABLE 2.—RATE AND EXTENT OF SOLUBILITY OF A CLAY LOAM TREATED WITH SALTS AND THEN WASHED UNTIL ALL THE FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	.1	1	2	4	7	10	14	21	29	36	49	72	102
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.006	.008	.010	.016	.020	.024	.031	.030	.030	.031	.031	.032	.035
$NaNO_3$	.010	.022	.030	.039	.050	.063	.063	.075	.088	.088	.090	.090	.092
KNO_3	.006	.010	.014	.019	.030	.034	.035	.042	.052	.052	.053	.053	.055
KCl	.006	.010	.014	.019	.030	.038	.040	.052	.055	.058	.062	.073	.075
K_2SO_4	.010	.012	.015	.020	.030	.034	.042	.052	.062	.062	.061	.063	.066
$(NH_4)_2SO_4$	.015	.042	.049	.050	.054	.060	.065	.075	.089	.081	.085	.086	.075
$MgSO_4$	.006	.012	.013	.014	.020	.023	.031	.042	.058	.058	.062	.068	.070
$CaH_4(PO_4)_2$	.010	.015	.015	.016	.024	.025	.027	.028	.026	.027	.028	.027	.026
KH_2PO_4	.009	.017	.016	.018	.025	.026	.028	.035	.045	.043	.050	.050	.051
$NaC_2H_3O_2$	.009	.014	.018	.020	.030	.047	.052	.067	.073	.084	.092	.103	.110
Check	.010	.016	.018	.020	.025	.029	.032	.038	.037	.041	.040	.038	.040

Plate 1. Rate and extent of solubility of Wis. Superior Clay.

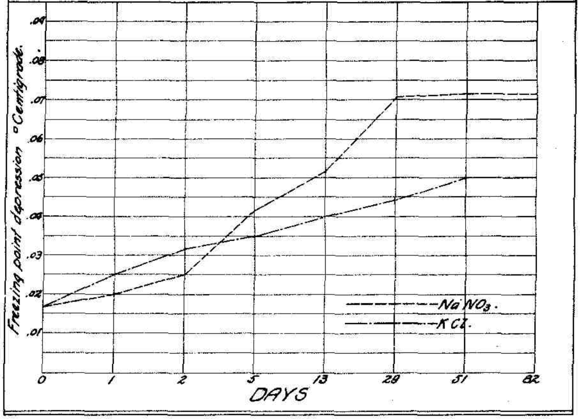


Plate 2. Rate and extent of solubility of clay loam No 1.

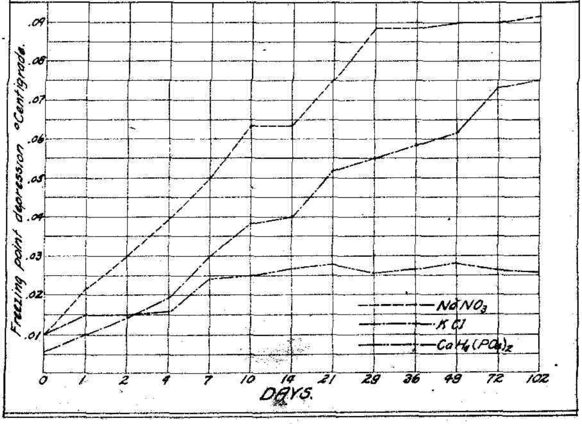


TABLE 3.—RATE AND EXTENT OF SOLUBILITY OF A CLAY LOAM TREATED WITH SALTS AND THEN WASHED UNTIL ALL THE FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	2	4	8	12	19	26	34	47	70	100
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.005	.006	.011	.010	.018	.018	.020	.020	.022	.022	.022
$NaNO_3$	.011	.011	.017	.022	.627	.043	.043	.058	.059	.067	.075
KNO_3	.005	.006	.018	.021	.020	.033	.033	.038	.038	.047	.050
KCl	.008	.009	.019	.021	.022	.031	.034	.039	.088	.040	.041
K_2SO_4	.010	.016	.021	.022	.024	.031	.035	.039	.039	.050	.052
$(NH_4)_2SO_4$	.021	.046	.045	.046	.046	.051	.053	.053	.053	.051	.040
$MgSO_4$	.005	.006	.010	.011	.010	.016	.023	.028	.028	.029	.030
$CaH_4(PO_4)_2$	.007	.007	.015	.015	.015	.015	.016	.015	.016	.015	.015
KH_2PO_4	.012	.012	.015	.015	.015	.015	f014	.015	.016	.015	.015
$NaC_2H_3O_2$	.012	.016	.030	.031	.032	.045	.053	.058	.063	.070	.080
Check	.003	.006	.010	.011	.011	.013	.018	.028	.028	.028	.032

TABLE 4.—RATE AND EXTENT OF SOLUBILITY OF A DARK BROWN SILT LOAM TREATED WITH SALT AND THEN WASHED UNTIL ALL FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	1	3	5	9	12	17	20	26	38	51	69	120
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.006	.007	.013	.017	.027	.030	.037	.036	.044	.060	.062	.060	.060
$NaNO_3$	.010	.015	.026	.036	.047	.052	.055	.056	.074	.080	.087	.088	.089
KNO_3	.010	.012	.023	.031	.047	.047	.050	.051	.056	.070	.074	.085	.087
KCl	.010	.013	.022	.031	.042	.045	.043	.053	.056	.070	.074	.080	.082
K_2SO_4	.010	.012	.023	.031	.044	.047	.050	.055	.065	.080	.084	.095	.095
$(NH_4)_2SO_4$	.020	.030	.043	.042	.049	.051	.050	.056	.066	.080	.089	.088	.080
$MgSO_4$	.008	.010	.013	.022	.030	.040	.038	.046	.051	.060	.064	.065	.068
$CaH_4(PO_4)_2$	.010	.010	.015	.022	.027	.035	.037	.038	.046	.050	.052	.052	.055
KH_2PO_4	.010	.018	.020	.027	.030	.038	.041	.045	.048	.053	.055	.057	.059
$NaC_2H_3O_2$	.010	.018	.030	.034	.052	.060	.067	.072	.076	.090	.094	.110	.110
Check	.005	.008	.073	.015	.027	.032	.037	.036	.044	.046	.048	.050	.051

Plate 3. Rate and extent of solubility of clay loam No. 2.

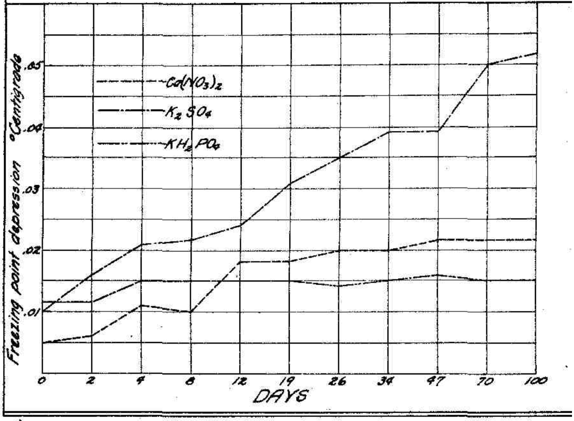


Plate 4. Rate and extent of solubility of a dark brown silt loam No. 1.

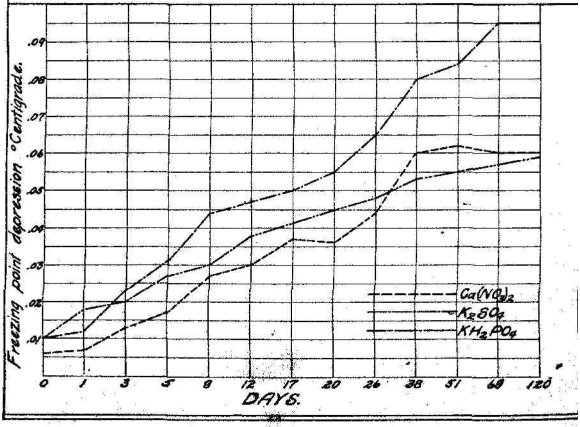


TABLE 5.—RATE AND EXTENT OF SOLUBILITY OF A DARK BROWN SILT LOAM TREATED WITH SALTS AND THEN WASHED UNTIL ALL THE FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days	0	1	4	8	11	15	19	25	36	53	68	119
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.005	.006	.012	.023	.026	.034	.039	.040	.046	.050	.054	.055
$NaNO_3$	.005	.016	.032	.053	.055	.072	.077	.082	.084	.107	.108	.110
KNO_3	.005	.016	.031	.040	.045	.059	.059	.058	.076	.090	.086	.091
KCL	.005	.011	.029	.034	.045	.059	.064	.065	.068	.072	.078	.080
K_2SO_4	.005	.014	.032	.043	.050	.064	.065	.065	.076	.084	.089	.090
$(NH_4)_2SO_4$	.010	.024	.044	.053	.055	.056	.058	.055	.065	.067	.069	.060
$MgSO_4$	.005	.006	.015	.028	.035	.038	.039	.043	.057	.062	.032	.060
$CaH_4(PO_4)_2$	.005	.006	.016	.023	.030	.032	.031	.038	.046	.047	.048	.044
KH_2PO_4	.005	.006	.018	.033	.036	.042	.043	.046	.056	.052	.060	.067
$NaC_2H_3O_2$	.005	.014	.032	.053	.060	.082	.081	.081	.095	.100	.110	.110
Check	.005	.006	.012	.023	.027	.031	.038	.039	.041	.043	.046	.046

TABLE 6.—RATE AND EXTENT OF SOLUBILITY OF A FINE SANDY LOAM TREATED WITH SALTS AND THEN WASHED UNTIL ALL THE FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	1	3	6	9	13	21	31	45	62	114
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.005	.007	.010	.016	.020	.024	.037	.039	.045	.048	.050
$NaNO_3$	.005	.015	.018	.036	.040	.051	.072	.077	.082	.098	.101
KNO_3	.005	.012	.015	.026	.035	.042	.060	.072	.080	.085	.085
KCl	.005	.012	.017	.028	.038	.043	.061	.066	.070	.073	.068
K_2SO_4	.005	.014	.017	.027	.040	.044	.063	.068	.072	.083	.078
$(NH_4)_2SO_4$	.009	.025	.030	.040	.040	.050	.062	.066	.062	.062	.055
$MgSO_4$	.004	.006	.010	.014	.020	.025	.042	.048	.051	.062	.075
$CaH_4(PO_4)_2$	.004	.006	.008	.010	.017	.022	.030	.034	.038	.042	.040
KH_2PO_4	.004	.007	.017	.017	.026	.033	.042	.049	.052	.060	.058
$NaC_2H_3O_2$	.005	.014	.025	.030	.045	.052	.069	.079	.080	.093	.092
Check	.005	.006	.008	.015	.024	.032	0.34	.035	.037	.040	.040

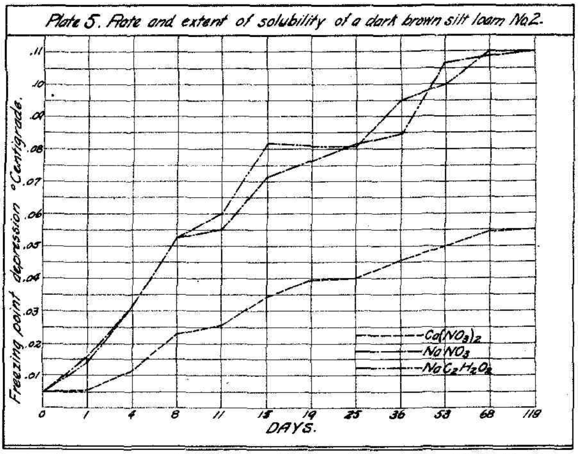


Plate 5. Rate and extent of solubility of a dark brown silt loam No. 2.

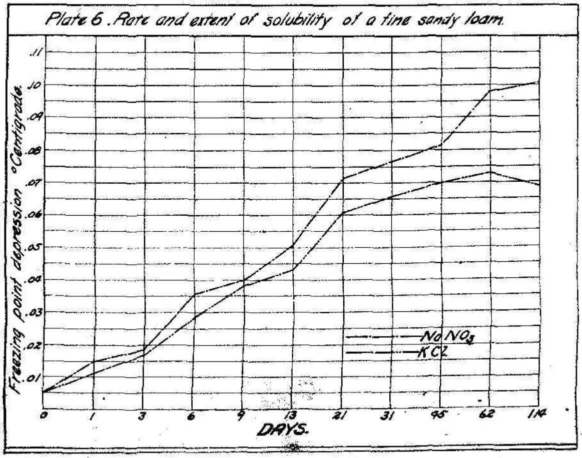


Plate 6. Rate and extent of solubility of a fine sandy loam.

TABLE 7.—RATE AND EXTENT OF SOLUBILITY OF SAND TREATED WITH SALTS AND THEN WASHED UNTIL ALL FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .7 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	1	2	3	10	20	50*	80
	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.004	.004	.004	.005	.006	.008	.008	.009
$NaNO_3$	.003	.005	.005	.005	.007	.009	.008	.009
KNO_3	.004	.004	005	.006	.006	.008	.008	.008
KCl	.003	.003	.005	.005	.006	.007	.007	.008
K_2SO_4	.004	.004	.004	.004	.005	.006	.008	.007
$(NH_4)_2SO_4$	.(03	.004	.004	.005	.004	.006	.007	.007
$MgSO_4$	.004	.004	.005	.004	.005	.005	.006	.008
$CaH_4(PO_4)_2$	.003	.003	.003	.004	.005	.005	.006	.006
KH_2PO_4	.003	.003	.003	.003	.005	.005	.005	.005
$NaC_2H_3O_2$	.003	.005	.005	.006	.006	.007	.008	.008
Check	.003	.003	.004	.005	.005	.006	.005	.006

The above data reveal many exceedingly interesting and very important and fundamental facts regarding the rate and extent of solubility of soils treated with various single salts and then washed, until all their free soluble salts were eliminated. In the first place it is immediately seen that the rate of solubility of all the soils with all the various single salts is very slow or that equilibrium is not attained very rapidly. The amount of material going into solution each day is slight and the process continues for a long time, even 120 days in some cases, but as a rule it tends to attain an apparent constancy at the end of about 60 days. The rate of solubility is not directly proportional to the time element, but tends to increase, on the whole, rather slowly and gradually with the time element, up to about 40 or 60 days, and then becomes more or less stationary or progresses very slightly thereafter. During the first four or five days the velocity of solubility appears to be slightly greater than at the succeeding days but the difference is very small except in a few cases. With the exception of the $(NH_4)_2SO_4$ treatments, the amount of material going into solution at the very beginning of the experiment does not exceed 200 parts per million of solution or .008°C depression, per day. The soils treated with $(NH_4)_2SO_4$ show the greatest velocity of solubility followed by $NaNO_3$, $NaC_2H_3O_2$, KNO_3, KCl, K_2SO_4, $MgSO_4$, $Ca(NO_3)_2$, KH_2PO_4 and $CaH_4(PO_4)_2$. The order of the last nine salts is not always exactly the same, but there is a general tendency towards that order. *The interesting fact to be noted is that* the rate of solubility of nearly all the soils treated with $Ca(NO_3)_2$, KH_2PO_4, and $CaH_4(PO_4)_2$ is about the same as that of the untreated soils or checks. *These three salts, therefore, and especially* the $CaH_4(PO_4)_2$ did not increase the rate of solubility of soils as did the other salts. The greater velocity of solubility of the soils treated with the *$(NH_4)_2SO_4$ is only of short duration.*

In the second place the preceding experimental data show that the extent of solubility is very considerable in all the salt treatments and in all of the soils, with few exceptions. All the soils, except sand, treated with $NaNO_3$ KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, and $NaC_2H_3O_2$ yielded quite a large amount of material to solution by the end of the experiment. Thus, the depression of many of these salts rose from about .005° to about .110°C or from 125 to 2750 parts per million. The only salt treatments which did not cause a large solubility product were the $Ca(NO_3)_2$, KH_2PO_4, and $CaH_4(PO_4)_2$. The depression in some of these salt treatments rose only from about .007° to 015C or from 175 to 375 parts per million of solution. Considering the solubility products of each salt treatment and taking the check for basis of comparison it is evident that the amount of material that goes into solution varies considerably between the various salt treatments within any one soil, except sand. As a rule $NaNO_3$, and $NaC_2H_3O_2$ treatments yielded the greatest solubility product, the $Ca(NO_3)_2$, KH_2PO_4 and $CaH_4(PO_4)_2$ the smallest and the KNO_3, KCL, K_2SO_4, $(NH_4)_2SO_4$ and $MgSO_4$ an intermediate. In many soils the $CaH_4(PO_4)_2$ and in a few soils the $Ca(NO_3)_2$ and KH_2PO_4 *treatments did not only give the smallest concentrations but* even a smaller concentration than the check. Evidently these salt treatments tended to have an indifferent or depressing effect upon the solubility of soils. Besides there being a difference in the extent of solubility between the various salt treatments within the same soil there is also a difference in the extent of solubility between the various soils treated with the same salt. Between the clays, clay loams, silt loams and sandy loams, this difference is not very marked, but between these classes of soil and sand the difference is very great. Indeed, the extent of solubility of sand treated with the various salts is practically negligible. Thus, the depression rises only from 003° to .010°C as compared to the depression of from .005° to .110° in some of the other soils. The salt treatments of sand therefore, had practically no effect upon its solubility.

The study on the rate and extent of solubility of soils treated with salts and then washed until all their free soluble salts were eliminated seems to prove quite conclusively the two general facts, (1) the rate of solubility of the treated soils is comparatively very slow and gradual and the process continues for a long time, but usually about 60 days, and (2) the extent of solubility of these same soils is very considerable, with few exceptions.

Now it would be highly interesting and very important to know what the chemical composition is of the material that goes into solution in the different soils treated with the various salt solution. Unfortunately the freezing point method does not itself yield any information upon this point and consequently no definite statements can be made on it. It may be stated, however, that this problem is now being investigated by Spurway in this laboratory and he finds that the substances which go into solution consist principally of the base radical of the salt added, of aluminum, iron, calcium, magnesium, potassium, phosphorus, and organic matter. The amount of the base radical of the salt added always predominates, but the amount and presence of other constituents varies with the soil and salt added.

In treating the soils with salts there were many objects in view. Besides measuring the rate and extent of solubility of the treated soils it was desired to study at least three other subjects, namely, (1) residual effect of salt or fertilizer treatment upon the rate and extent of solubility of soils; (2) the possibility of employing the solubility factor as a criterion for the state of fertility of soils, and thereby distinguishing between good and poor soils, and (3) the character of the reaction between soils and salts, i. e., whether it is chemical or physical.

As to the first subject the experimental results presented show that with the exception of $Ca(NO_3)_2$, KH_2PO_4, and $CaH_4(PO_4)_2$ all the other salts, which include $NaNO_3$, KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, and $NaC_2H_3O_2$, leave a residual effect upon the soils which is manifested by the long and rather large amount of material going into solution in all the soils, except in sand. This residual effect goes to prove that when a soil is treated with a soluble salt a certain combination takes place between the soil and the salt or its ions, that upon washing, this salt or its ion is not carried away and that in this combination the solubility of the soil is changed. These experimental facts confirm the validity of the various practical observations that when a soil is treated with soluble fertilizers the fertilizer is not all washed away but leaves a residual effect which persists for a long time, as manifested by the continued increased growth of crops. Witness, for instance, the residual effects of the various fertilizers at the Rothamsted Experiment Station.

Because the salt treatments of $Ca(NO_3)_2$, KH_2PO_4 and $CaH_4(PO_4)_2$ did not cause an increase in solubility of soils, it cannot be concluded that these salts did not leave a residual effect upon the soils. These salts did also leave a residual effect upon the soils, but their residual effect apparently is not shown in the solubility of the soils, but it is in the crop production.

As to the second subject, the experimental data also show that the solubility factor may be taken as a criterion for the state of fertility of a soil, and consequently for distinguishing between a rich and a poor soil. As will be seen, the results show that with the exception of the salt treatments of $Ca(NO_3)_2$, KH_2PO_4, and $CaH_4(PO_4)_2$ all the other salt treatments caused a considerable increase in the solubility product over the check. In many cases the increase is over .070° C freezing point depression or 1750 parts per million of solution. From these marked increases in the solubility product over the check it would be logically inferred that a heavily fertilized or very rich soil gives more material to solution than an unfertilized or poor soil.

The last inference or conclusion, however, cannot be rigidly adhered to. On account of the exceptions already mentioned and a few others to be mentioned later on, it cannot be claimed that the solubility factor is an absolute and reliable criterion of the fertility of a soil. As a matter of fact it is not only the amount of material that goes readily into solution which makes a soil fertile, but also the kind of material that goes into solution. As it is now understood the soil solution must be properly balanced in the various food elements used by the plant, in order that a soil may be really called a fertile soil. If the material that goes into solution does not form a properly balanced plant food medium,

even though the total quantity is very large, the soil cannot be rightly designated a fertile soil. According to the law of minimum, if one plant food elements is lacking either totally or partially and all the other plant food elements are present in abundance, the lacking element becomes the limiting factor, the plant growth is affected and consequently the soil is rightly designated an infertile soil. Again, the phosphates not only do not go into solution in any large amounts or increase the solubility of soils as the other single salts, but they appear to have a depressing effect upon the solubility of soils. As has already been seen, in none of the soils treated with $CaH_4(PO_4)_2$ was the solubility product greater than that of the check and in some cases, it was actually much smaller. Now it can hardly be asserted that these soils which show small solubility are made infertile by the addition of phosphorus. On the contrary they are as fertile as the corresponding soils which received the other salt treatments and which gave a large solubility product. These soils, therefore, are fertile but this fertility power is not indicated by the solubility factor because of the depressing effect of the phosphorus. This depressing effect is doubtless due to the combination of phosphorus with the bases of the soil and the decreased solubility of the latter. It is now generally believed that the fixation of phosphorus in the soil depends upon the presence and abundance of bases. When phosphorus combines with these bases not only the phosphorus is fixed, but evidently the bases also become less soluble. If this is true then phosphorus acts as a conserver of bases, and thereby prevents the rapid loss of bases through leaching which ultimately and inevitably results in the creation of an acid condition of soils. On the other hand, it must be stated that when a soil was treated with a combination of several salts such as $Ca(NO_3)_2$, $NaNO_3$, KNO_3 KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, $CaH_4(PO_4)_2$, KH_2PO_4 and $NaC_2H_3O_2$, the phosphates did not have a very marked depressing effect upon the solubility, but when $(NH_4)_2SO_4$, $NaC_2H_3O_2$ were eliminated from the combination then the depressing effect became very marked. Evidently the ammonia radical of the $(NH_4)_2SO_4$ and the acetate radical of the $NaC_2H_3O_2$ were not influenced by the phosphorus. Finally, that the solubility factor may not be an absolute and reliable criterion of the fertility of the soil is further found in the possibility that the plants may not obtain all their plant food entirely from the soil solution but also from the solid matter itself—the soil particles. Although at present the general belief appears to be that the plants do not themselves obtain any plant food directly from the solid soil except that which is made soluble by the excreted carbon dioxide, yet the writer believes that the plants must in some way derive part of the plant food directly from the soil particles and especially in the case of some of the soils such as clay.

In spite of these limitations, however, it must be admitted that in general a high soluble salt content which is due partly if not largely to a high solubility, is associated with a high state of fertility. This fundamental principle is abundantly supported by a large amount of experimental data. The work of King[2], Hall, Brenchley, and Underwood[3],

(2) Investigation in soil Management, 1904. Madison, Wis.
(3) Phil. Trans, Roy. Soc. London. Ser. B. V. No. 307, p. 179 (1913).

seems to afford a conclusive proof of this principle. The recent investigation of Jordan[4], Burd, Stewart and Hoagland[5] also lead to the same conclusions.

It may be stated then as a general principle that while the solubility factor is not an absolute and reliable criterion for the state of fertility of a soil, a very rich or heavily fertilized soil tends to give a high solubility product or a high soluble salt content.

Mention has been made that in employing salt treatments in the study of the rate and extent of solubility it was hoped to be able to throw some light on the character of the reaction between soils and salts—i. e.—whether it is chemical or physical. As is well known, this question still remains unsolved and the scientific opinion on it is very much divided. Some believe that the action is chemical, others that it is physical. It was thought, therefore, that the study of the rate and extent of solubiliy of treated soils might help to solve this problem. It was reasoned that if the reaction was chemical so that the salt or its ion combined with the soil to form new chemical compounds, the rate of solubility of this treated soil should be slow and gradual since the rate of solubility of many definite soluble compounds such as $CaH_4(PO_4)_2$, K_2SO_4, etc., is slow and gradual. If on the other hand, the reaction is physical so that the salt or its ion was merely absorbed or condensed on the surface of the soils, probably in a film form, then the rate of solubility of the soil should be very fast and the equilibrium should be attained in a very short time probably in a few minutes. The latter reasoning was supported by the fact that an adsorbed film should go into solution faster than a difficult soluble chemical compound and especially since an adsorbed material generally follows the law of equal distribution, i. e., between the solid and liquid phase.

If the difference in the rate of solubility of salt treated soils is a true criterion for distinguishing between chemical and physical reaction then the evidences are overwhelmingly in favor of the theory that the reaction between soils and salts or their ions is chemical and not physical. For it is readily seen that in all the soils with all the salts the rate of solubility is very slow and gradual, extending usually to 60 days and in some cases even to 120 days. This chemical theory is further supported by the chemical composition of the material going in solution. As already stated this material consists of the base radical of the salt added, of aluminum, iron, calcium, magnesium, phosphorus and organic matter. Now if the reaction were physical, the resulting solubility product ought to be composed largely of the material adsorbed.

Referring once more to the experimental data, the questions may be asked, has the solubility attained equilibrium and has the solution become saturated?

Before an attempt is made to answer these questions it is necessary to recall that the soils were kept in stoppered glass tubes at a moisture content of about 1 of soil to about .70 water. These conditions of the experiment, therefore, were very favorable for maximum true solubility but very unfavorable to nitrification actions, although perhaps somewhat favorable to denitrification and to other types of biological action. It is believed, however, that under the condition of the experiment bio-

(4) N. Y. State Agr. Expt. Sta. Bul. 424. (1916)
(5) Journ. Agr. Res. V. 12, No. 6 (1918).

logical activities of any kind were at minimum, especially the first ten days.

With the above explanation in mind the questions now may be answered. From the data it would appear that equilibrium is attained at the end of about 60 days, as at this period solubility becomes stationary or negligible. And if equilibrium is attained then the solution must also be saturated, at least with some of the soil constituents.

While the results show an apparent equilibrium there are many evidences which seem to make doubtful if it is the real equilibrium. In *the first place, if the soil which shows a constancy in solubility at the* high water content is allowed to lose moisture so that its water content is reduced to about the optimum point, the freezing point depression or the *amount of material in solution is far greater* than at the high moisture content where equilibrium is shown to have been reached. Now according to the laws of solubility, if the solution were at equilibrium and saturated at the high moisture content the solution should become super-saturated at the lower moisture content and the solutes should separate out so that the solution would again be at equilibrium and saturated as required by the new conditions. In that event then the freezing point depression at the low moisture content should be the same as that at the high. Instead of that, the depression, as has already been stated is much greater at the low moisture content.

In the second place, since the soil is a complex and heterogeneous mass, composed of minerals, colloids, organic matter, etc., it does not seem possible that it forms definite chemical compounds with the salts. And if it does not form definite chemical compounds it probably does not have a definite solubility, in the physical-chemical sense.

In the third place, since the soil contains organic matter it does not seem reasonable to believe that definite equilibrium, in the physical-chemical sense, is attained.

The conclusion appears inevitable, therefore, that the equilibrium indicated *by the experimental data is not a true and definite equilibrium in the physical-chemical sense, but only an apparent equilibrium.* The true equilibrium is probably never attained because many salts formed in the soil, such as $NaNO_3$, KCl, Na_2CO_3, $CaSO_4$, etc., have a very high solubility constant and a tremendous amount of them is required to form a saturated solution. Furthermore, if the soil is considered as it actually is and not speaking from theoretical principles, it is probably not proper to speak of true equilibrium, in a chemical-physical sense. This logically follows from the fact that the soil is a heterogeneous mix*ture composed of mineral solids, organic matter, gas, and a liquid,* and contains organisms, and in the process of solution, hydrolysis, biological decomposition, etc., many substances are formed, which once formed do not *depend in their solubility upon the substance from which* they were formed, and consequently there cannot be a true solubility as is chemically understood.

The solubility *of the soils under consideration would probably* continue for many months, if not almost indefinitely, if it were not for some factors which create a limitation in the amount of material going into solution, and after a certain time cause even a reverse action. Just what these factors are is not known, but some may be suggested. It has

been observed in the first place, that after the soils have stood in the tubes for 50 or 60 days algae begin to appear on the sides of the tubes above the soil. The column of water standing on the top of the soil, after the latter settles, becomes sometimes turbid and occasionally a red precipitate appears in this column of water of some of the soil or salt treatments. At about this stage, the solubility becomes more or less constant and in some cases a reverse action takes place, i. e., there *is a sudden or gradual reduction in the freezing point depression, indicating* that some material in solution is going out of solution. The red precipitate occurs very generally in the untreated soil and only occasionally in the treated soils, and when it occurs it stains the glass of the tube and this stain becomes fixed as it cannot be washed with water. While it is not definitely known what the cause of this red precipitate is, it seems to be brought about by living organisms. The reverse action takes place sometimes even when there is no precipitate of any kind. This happens invariably in the case of the soil treated with $(NH_4)_2SO_4$. *The concentration of the solution continues to increase in this case for* about 40 or 50 days and then quite suddenly it decreases. The reverse action took place only in those soils treated with $(NH_4)_2SO_4$ and not in the other salt treatments.

Another factor which seems to limit or prevent further solubility as indicated by the progressive increase of concentration is the concentration of the solution itself. It was found, for instance, that when a soil was treated with a salt and the salt was only partially washed with water the original depression remained quite stationary or constant, while if all the salts were washed away, the original depression was greatly increased. Evidently the presence of a high concentration prevents the soil from yielding to the solution even the amount of the material that it would in an untreated condition. This conclusion is further supported by the results of a former investigation on the measurement of the velocity of the reaction between soils and chemical agents and the behavior of equilibrium. It was shown in this research that the velocity of the reaction between soils and salts was extremely rapid if not almost instantaneous, and the equilibrium attained remained constant for long times, even one hundred days. Now if the soils were yielding material to the solution this equilibrium certainly could not be maintained constant for such long periods of time.

If concentration, therefore, tends to inhibit solubility then the further solubility of the *salt-treated soil was retarded or completely stopped* by the concentration of its own solution. The solubility went on until a certain concentration was reached and then this degree of concentration had an opposite effect upon the solubility and it either completely stopped it or greatly retarded it.

In what manner the concentration affects unfavorably the solubility of the soil cannot be stated at present. It may be argued that the solubility still goes on but that the soil readsorbs some of the material in the solution, or that the soluble materials react between themselves and *form new compounds, or precipitate one another, and these pro*cesses are so balanced that the total concentration remains the same for a long time. In view of the effect of total solids upon the depression,

(6) Mich. Agr. Expt. Sta. Tech. Bul. 37 (1917).

the difference in ionization of the different compounds and the consequent difference in the freezing point depression, it does not seem possible that these processes could be going on without causing a change or fluctuation in the lowering of the freezing point. Wherever a change occurs the method detects it, as in the case where a reverse action takes place.

To conclude then, it seems probable that the solubility of the soils under consideration would continue much further than it did, but on account of some opposing factors it comes to a standstill after a certain length of time. Some of the opposing factors are the living organisms in the soil, the concentration of the solution itself and the adsorptive power of the soil.

Finally, it must be emphasized that the above and other factors do not diminish the fundamental importance of the experimental results of this investigation from both the practical and scientific standpoints. *In the first place, the most important fundamental principle on the rate* and solubility from both the practical and scientific standpoint are established at the beginning and especially at the first or second day of the experiment, and the factors mentioned above do not come into play for a long time; and in the second place the method employed in obtaining these experimental results is essential and desirable for a complete and comprehensive study of the rate and extent of solubility of soils both treated and untreated. As will be seen subsequently this method is checked by a method which aims to simulate field conditions, and thus affords a comparison in the results between the two methods.

From the practical standpoint the rate and extent of solubility in the first and second day are the most important because they show the possible rate and amount of material which goes in solution for the use of the plant. During this time there was no biological action in these soils which affected the results.

Rate and Extent of Solubility of Soils Treated with a Combination of Salts and then Washed Until the Free Soluble Salts Were Eliminated. Ratio of Soil to Water was about 1 to .7 and Mixture Maintained at Room Temperature.

In the preceding study only single salts were employed. In the present study a combination of salts was employed. This combination of salts comprised all the single salts used previously, namely, $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, $CaH_4(PO_4)_2$, KH_2PO_4, *and* $NaC_2H_3O_2$. The strength of this solution was tenth normal, the same as of the single salt solutions. The soils were exactly the same as before. The procedure of treating the soils and measuring the rate and extent of solubility was also the same as in the preceding study. The results obtained are presented in table 8. This table contains the rate and extent of solubility as indicated by the freezing point depressions of the treated and untreated soils.

TABLE 8.—RATE AND EXTENT OF SOLUBILITY OF SOILS TREATED WITH A COMBINATION OF ALL TEN SALTS AND THEN WASHED. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days	0	1	2	4	8	13	20	27	36
	C°	C°	C°	C°	C°	C°	C°	C°	C°
Superior clay, treated	.009	.017	.023	.030	.034	.038	.040	.043	.045
Superior clay, untreated	.006	.008	.010	.014	.014	.016	.018	.020	.022
Clay loam, treated	.008	.020	.028	.035	.047	.050	.052	.051	.052
Clay loam, untreated	.006	.008	.008	.010	.014	.018	.019	.022	.022
Dark brown silt loam, treated	.009	.028	.034	.043	.060	.072	.077	.078	.080
Dark brown silt loam, untreated	.006	.008	.013	.027	.032	.035	.037	.041	.045
Dark brown silt loam, treated	.008	.022	.032	.040	.050	.062	.073	.075	.078
Dark brown silt loam, untreated	.007	.008	.010	.012	.023	.037	.038	.039	.042
Sandy loam, treated	.008	.020	.029	.030	.040	.052	.060	.063	.070
Sandy loam, untreated	.003	.006	.010	.012	.017	.024	.027	.032	.032
Sand, treated	.003	.003	.003	.004	.005	.005	.005	.006	.006
Sand, untreated	.003	.003	.003	.004	.005	.005	.005	.006	.006

The above data show very conclusively and strikingly that even when the soils are treated with a combination of salts the rate of solubility is slow and gradual and the process continues for a long time, and that the extent is considerable and much greater than that of the untreated soils.

The above results also show that when the soils are treated with a combination of all the salts mentioned the phosphates do not inhibit the solubility of the soils as they do when they are added themselves singly.

On the other hand it must be stated that when $(NH_4)_2SO_4$ and $NaC_2H_3O_2$ are omitted from the combination the extent of solubility is much less than it is when they are present—indicating that it is probably the ammonia and the acetate radicals which bring about the difference. Evidently the phosphates do not control the amount of material going into solution when $(NH_4)_2SO_4$ and $NaC_2H_3O_2$ are present.

Rate and Extent of Solubility of Experimental Field Soils which have Been Receiving Fertilizer Treatments in the Usual Manner. Ratio of Soil to Water was about 1 to .7 and Mixture Maintained at Room Temperature.

Having established certain fundamental principles regarding the rate and extent of solubility of soils treated with salts singly and in combination it was deemed important and essential to try to verify these principles with natural field soils which have been receiving fertilizer treatment in the usual way and whose culture history and state of fertility are known. For this purpose soil samples from the standard experimental fields of the University of Illinois, Cornell University, Ohio Experiment Station and Rhode Island Agricultural College were obtained.

(a) *For procuring these soils the writer is most thankful and very indebted to Dr. Lyon of Cornell University, Dr. Hopkins and Dr. Stewart of the University of Illinois, Professor Ames of the Ohio Experiment Station and Director Hartwell of the Rhode Island Experiment Station.*

These soils were received in the fresh state and were used in that condition. Certain quantities of them were placed on filter papers in funnels and washed until all their free soluble salts were eliminated and their freezing point depression was very close to that of distilled water. A portion of each washed soil was then placed in the freezing point tube, water being added to it to bring up the water content to the ratio of about 1 or soil to .7 of water, and the freezing point depression was determined immediately and as often thereafter as was deemed necessary. The data secured are presented in tables 9 to 14, inclusive. Below each table is a description of the fertilizer treatment of the respective soils.

TABLE 9.—RATE AND EXTENT OF SOLUBILITY OF RHODE ISLAND SOILS. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .60 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	1	2	4	7	10	17	24	31	45	61
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
Soil No. 1	.010	010	.010	.012	014	.020	.020	.020	.023	.025	.025
Soil No. 2	.010	.010	010	.012	.021	.022	.023	.023	.025	.028	.029
Soil No. 3	.010	.010	.010	.012	.014	.022	.022	.022	.023	.025	.028
Soil No. 4	.010	.011	.011	.014	.020	.022	.021	.022	.025	.029	.031
Soil No. 5	.010	.010	.010	.012	.012	.012	.013	.012	.012	.013	.015
Soil No. 6	.010	010	.010	.012	.010	.011	.011	.011	.011	.011	.012
Soil No. 7	.010	.012	012	.011	.017	.019	.020	.020	.022	.024	.025

Soil No. 1. 158 pounds nitrate of soda, 96 pounds sulfate of ammonia, 450 pounds tankage, 571 pounds acid phosphate, 97 pounds sulfate of potash, lime.
Soil No. 2. 127 pounds nitrate of soda, 574 pounds acid phosphate, 200 pounds salt, 856 pounds wood ashes, lime.
Soil No. 3. 127 pounds nitrate of soda, 96 pounds sulfate of ammonia, 753 pounds tankage, 659 pounds acid phosphate, 200 pounds salt, 1484 pounds wood ashes, lime.
Soil No. 4. 191 pounds nitrate of soda, 144 pounds sulfate of ammonia, 301 pounds tankage, 444 pounds double superphosphate, 131 pounds magnesium sulfate, 103 pounds sulfate of potash, lime.
Soil No. 5. Same as No. 4 without lime.
Soil No. 6. No fertilizers, almost a virgin soil.
Soil No. 7. Virgin soil.

TABLE 10.—RATE AND EXTENT OF SOLUBILITY OF OHIO SOILS. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	2	5	9	16	23	30	44	61
	C°	C°	C°	C°	C°	C°	C°	C°	C°
Soil No. 1	.010	.014	.020	.022	.028	.032	.040	.040	.040
Soil No. 2	.010	.016	.020	.022	.022	.028	.030	.030	.032
Soil No. 3	.010	.016	.020	.021	.023	.022	.030	.030	.031
Solil No. 4	.010	.012	.013	.014	.015	.016	.018	.018	.020
Soil No. 5	.010	.012	.013	.014	.015	.015	.018	.018	.020
Soil No. 6	.010	.016	.020	.021	.020	.020	.028	.028	.030
Soil No. 7	.010	.016	.020	.022	.020	.028	.033	.032	.033
Soil No. 8	.010	.016	.020	.022	.023	.025	.028	.028	.030

Soil No. 1. Five year rotation, in corn, unfertilized.
Soil No. 2. Five year rotation, in corn, plot 2; acid phosphate 80 pounds.
Soil No. 3. Five year rotation, in corn, plot 12; acid phosphate 160 pounds; muriate potash 80 pounds; nitrate soda 80 pounds.
Soil No. 4. Five year rotation, in oats, plot 15; acid phosphate 160 pounds; muriate potash 100 pounds; dried blood 50 pounds; nitrate soda 120 pounds.
Soil No. 5. Continuous culture, wheat unfertilized.
Soil No. 6. Continuous culture, wheat, plot 8; acid phosphate 100 pounds, muriate potash 100 pounds.
Soil No. 7. Three year rotation in potatoes; plot 15; acid phosphate 480 pounds, muriate potash 300 pounds, nitrate soda 320 pounds.
Soil No. 8. Three year rotation, in clover, plot No. 15, acid phosphate 480 pounds, muriate potash 300 pounds, nitrate soda 320 pounds, on potatoes only.

The 5 year rotation consisted of corn, oats, wheat, clover and timothy. The fertilizers have been applied only on the corn, oats and wheat, but not on the clover and timothy. In addition to the fertilizers stated above the soils have received also applications of lime at different periods.

TABLE 11.—RATE AND EXTENT OF SOLUBILITY OF ILLINOIS SOILS. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	1	3	6	10	17	24	31	45	61
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
Soil No. 1	.010	.013	.019	.023	.030	.038	.035	.042	.050	.050
Soil No. 2	.010	.012	.016	.019	.020	.020	.021	.022	.032	.032
Soil No. 3	.010	.011	.016	.019	.020	.020	.020	.021	.020	.025
Soil No. 4	.010	.011	.016	.023	.020	.030	.033	.035	.038	.040
Soil No. 5	.010	.011	.012	.013	.012	.013	.013	.013	.015	.017
Soil No. 6	.010	.011	.012	.012	.012	.012	.015	.017	.020	.020
Soil No. 7	.010	.010	.012	.016	.019	.020	.019	.021	.020	.030
Soil No. 8	.010	.011	.016	.021	.021	.022	.032	.040	.040	.040

South Farm

Soil No. 1. Plot No. 166. Residue, phosphorus, lime.
Soil No. 2. Plot No. 169. Residue.
Soil No. 3. Plot No. 170. Manure, phosphorus, lime.
Soil No. 4. Plot No. 173. Manure.

Davenport Plots

Soil No. 5. Plot No. 202. Residue.
Soil No. 6. Plot No. 203. Manure.
Soil No. 7. Plot No. 206. Residue, phosphorus, lime.
Soil No. 8. Plot No. 207. Manure, phosphorus, lime.

TABLE NO. 12.—RATE AND EXTENT OF SOLUBILITY OF CORNELL SOILS. RATIO OF SOILS TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	1	3	6	9	17	24	40	48	61
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
Soil No 1	.010	.012	.013	.019	.020	.020	.020	.021	.022	.024
Soil No. 2	.010	.012	.013	.019	.020	.020	.020	.020	.028	.030
Soil No. 3	.010	.012	.013	.019	.020	.018	.020	.020	.020	.022
Soil No. 4	.010	.012	.012	.018	.018	.018	.020	.019	.020	.022
Soil No. 5	.010	.012	.012	.019	.020	.020	.020	.022	.024	.036

Soil No. 1. Plot No. 720. No fertilizers.
Soil No. 2. Plot No. 721. 160 pounds nitrate of soda, 80 pounds muriate of potash, 320 pounds acid phosphate.
Soil No. 3. Plot No. 728. 640 pounds nitrate of soda, 80 pounds muriate of potash, 320 pounds acid phosphate.
Soil No. 4. Plot No. 730. No fertilizers.
Soil No. 5. Plot No. 732. 20 tons farm manure.
These soils were taken from plats used in rotation of timothy 3 years; corn, oats, and wheat. Fertilizers have been applied each to the three years of timothy, but no fertilizer has been given to the grain crops. On the manured plat, the manure has been applied twice to the three crops of timothy instead of three times as in the case of the common fertilizers.

Considering first the rate of solubility it is seen that the velocity is very slow and gradual in all the various soils, but in some it is considerably lower than in others. Thus, soils 5 and 6 in table 9, soil 4 and 5 in table 10 and soils 5 and 6 in table 11 manifest a much lower rate of solubility than the other soils. In fact, some of these soils, such as soils 5 and 6 in table 9, show an exceedingly slow rate of solubility.

Considering next the extent of solubility, it is evident that the amount of material that went into solution is rather small in practically all the soils and especially in those that show the least rate of solubility. The maximum quantity of material that went into solution increased only from a freezing point depression of .010° to .040° or .050°C at the end of 60 days.

Viewing next the solubility factor of these various salts in relation to their treatment or state of fertility, it becomes at once evident that there is no close and consistent relationship between these factors, just as there was not always one in the case of the salt treated soils. A comparison between the fertilizer treatment of the various soils and the quantity of the material that went into solution proves this fact quite conclusively. Thus, soils 4 and 5 in table 9, of the Rhode Island Experiment Station, had both received exactly the same fertilization except that soil 4 also received lime and soil 5 did not, and yet the amount of material that dissolved is very different in the two soils. In soil 4 the final depression is .030° while in soil 5 it is .015°C or only half as great. On the other hand, soil 6, which did not receive any fertilizer at all, did not yield any more material than the fertilized soils, as its depression is only .012°C, the lowest in the series.

Soil 1 in table 10, of the Ohio Experiment Station, received no fertilizer whatever, and yet it allowed more material to go into solution than the fertilized soils, its depression being .040° as compared to .033°C in soil 7. On the other hand, soil 5, which was also unfertilized but in continuous

wheat yielded only a small amount of material to solution, its depression being only .020°C. This depression, however, is the same as that in soil 4, which received heavy applications of fertilizers.

In the Cornell soils in table 12 the same inconsistency and irregularity are shown in the relationship. Soil 1 was unfertilized and yet it yielded as much material to solution as soils 3 and 4 which received fertilizers. Soils 5, however, which received manure gave the largest amount of soluble material, with soil 2 coming second.

Of all the sets of soils used those of the University of Illinois show the best consistency and regularity between treatment and solubility product. They show that soil 1 which received residual phosphorus and lime gave more soluble material than soil 2 which received only residue. Likewise, soil 4 which received manure, phosphorus and lime yielded a greater concentration than soil 3 which received only manure. Again soils 7 and 8 which received residue phosphorus and lime, and manure, phosphorus and lime respectively, produced more soluble material in the solution than soils 5 and 6 which received only residue and manure respectively. And the most important fact is that the order of the magnitude of the solubility product corresponds to the crop-producing power of the soils. On the other hand it must be stated that when an optimum moisture content is employed in these soils this fundamental principle is not confirmed, as data subsequently to be presented show.

In brief then, it can be said that there is no universal and consistent relationship between the factor of solubility and the state of fertility. Hence, the factor of solubility is not always an absolute and reliable criterion of the state of fertility of soils. This conclusion agrees with that already announced in connection with the salt treated soils, and is not at all surprising in view of the various disturbing factors pointed there. This conclusion finds further confirmation in the next phase of the investigation.

Rate and Extent of Solubility of Experimental Field Soils Which Have Been Receiving Fertilizer Treatments in the Usual Manner. Moisture Maintained at Optimum Content and Soils Kept Mostly Outdoors.

In the preceding series of experiments the rate and extent of solubility were studied at a very high moisture content, usually at the supersaturation point. While it is very important and highly desirable to so investigate the subject, yet this condition is artificial and does not simulate practical or field conditions. In the field the moisture content is greatly different and consequently the rate and extent of solubility may be much different. Before the principles established under the artificial condition can become applicable to field conditions, they must be tested out under field conditions.

Accordingly, the investigation on the rate and extent of solubility of experimental field soils which have been receiving fertilizer treatment in the usual manner, was repeated under practical conditions. The procedure consisted of placing a certain amount of the fresh soil on a filter paper in the funnel and washing with distilled water until all the free soluble salts of the soil were eliminated. A small sample of this soil was taken, air-dried, and its freezing point depression determined by using 15 grams of air dry soil and 10 c.c. of distilled water. The remainder of the soil was allowed to remain in the funnel undisturbed and to lose

water until its moisture content was reduced to about the optimum point. The soil then was placed in a glass tumbler, thoroughly stirred, weighed and water was added to it as often as it was deemed necessary in order to keep it at the optimum moisture content. In order to simulate further field conditions the soil was kept outdoors most of the time. At the end of 10, 30, and 60 days a small composite sample was taken, air-dried, and its freezing point depression determined as before. By determining the lowering of the freezing at the beginning and at the end of 10, 30, and 60 days, the rate and extent of solubility could thereby be ascertained. Also by using fresh soils and not disturbing them when wet their physical condition remained excellent and very much as under field conditions.

It is readily realized that under these favorable field conditions nitrification is very apt to take place in the soils and consequently an error may be introduced in the method of measuring the rate and extent of solubility of soils. While some nitrification undoubtedly took place in the soils yet the error introduced, as is revealed by the results, is practically negligible.

The data obtained in this phase of the investigation are presented in tables 13 to 16 inclusive. For purpose of convenience and immediate reference the fertilizer treatment of the soils is again given and is placed at the bottom of each respective table.

TABLE 13.—RATE AND EXTENT OF SOLUBILITY OF RHODE ISLAND SOILS AT OPTIMUM MOISTURE CONTENT, KEPT MOSTLY OUTDOORS. FIGURES REPRESEN FREEZING POINT DEPRESSION.

Days	*0*	*10*	*30*	*60*
	C°	C°	C°	C°
Soil No. 1	.008	.011	.025	.036
Soil No. 2	.008	.011	.020	.032
Soil No. 3	.008	.011	.020	.032
Soil No. 4	.008	.011	.020	.032
Soil No. 5	.008	.011	.020	.032
Soil No. 6	.008	.011	.020	.029
Soil No. 7	.008	.011	.025	.033

Soil No. 1. 158 pounds nitrate of soda, 96 pounds sulfate of ammonia, 450 pounds tankage, 571 pounds acid phosphate, 97 pounds sulfate of potash, lime.
Soil No. 2. 127 pounds nitrate of soda, 574 pounds acid phosphate, 200 pounds salt, 856 pounds wood ashes, lime.
Soil No. 3. 127 pounds nitrate of soda, 96 pounds sulfate of ammonia, 753 pounds tankage, 659 pounds acid phosphate, 200 pounds salt, 1484 pounds wood ashes, lime.
Soil No. 4. 191 pounds nitrate of soda, 144 pounds sulfate of ammonia, 301 pounds tankage, 444 pounds double superphosphate, 131 pounds magnesium sulfate, 103 pounds sulfate of potash, lime.
Soil No. 5. Same as No. 4 without lime.
Soil No. 6. No fertilizers, almost a virgin soil.
Soil No. 7. Virgin soil.

TABLE 14.—RATE AND EXTENT OF SOLUBILITY OF OHIO SOILS AT OPTIMUM MOISTURE CONTENT. KEPT MOSTLY OUTDOORS. *FIGURES REPRESENT FREEZING POINT DEPRESSION.*

Days.	0	10	30	60
	C°	C°	C°	C°
Soil No. 1	.009	.012	.020	.027
Soil No 2	.009	.012	.017	.027
Soil No. 3	.009	.012	.020	.027
Soil No. 4	.009	.012	.020	.027
Soil No. 5	.009	.012	.016	.025
Soil No. 6	.009	.012	.020	.026
Soil No. 7	.009	.012	.020	.025
Soil No. 8	.009	.012	.020	.026

Soil No. 5. Five year rotation, in corn, unfertilized.
Soil No. 2. Five year rotation, in corn, plot 2; acid phosphate 80 pounds.
Soil No. 3. Five year rotation, in corn, plot 12; acid phosphate 160 pounds; muriate potash *80 pounds; nitrate soda 80 pounds.*
Soil No. 4. Five year rotation, in oats, plot 15; acid phosphate 160 pounds; muriate potash 100 pounds; dried blood 50 pounds; nitrate soda 120 pounds.
Soil No. 5. Continuous culture, wheat unfertilized.
Soil No. 6. Continuous culture, wheat, plot 8; acid phosphate 100 pounds, muriate potash *100 pounds.*
Soil No. 7. Three year rotation in potatoes; plot 15; acid phosphate 480 pounds; muriate potash 300 pounds, nitrate soda 320 pounds.
Soil No. 8. Three year rotation, in clover, plot No. 15, acid phosphate 480 pounds, muriate potash 300 pounds, nitrate soda 320 pounds, on potatoes only.

The 5 year rotation consisted of corn, oats, wheat, clover and timothy. The fertilizers have been applied only on the corn, oats, and wheat, but not on the clover and timothy. In addition to the fertilizers stated above the soils have received also applications of lime at different periods.

TABLE 15.—RATE AND EXTENT OF SOLUBILITY OF ILLINOIS SOILS AT OPTIMUM MOISTURE CONTENT. KEPT MOSTLY OUTDOORS. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	10	30	60
	C°	C°	C°	C°
Soil No. 1	*.009*	*.012*	*.022*	*.029*
Soil No 2	.009	.012	.020	.028
Soil No. 3	.009	.012	.020	.026
Soil No. 4	.009	.012	.020	.026
Soil No. 5	.009	.012	.020	.026
Soil No. 6	.009	.012	.020	.026
Soil No. 7	.009	.012	.020	.027
Soil No. 8	*.009*	*.012*	*.020*	*.029*

South Farm

Soil Uo. 1. Plot No. 166. Residue, phosphorus, lime.
Soil No. 2. Plot No. 169. Residue.
Soil No. 3. Plot No. 170. Manure, phosphorus, lime.
Soil No. 4. Plot No. 173. Manure.

Davenport Plots

Soil No. 5. Plot No. 202. Residue.
Soil No. 6. Plot No. 203. Manure.
Soil No. 7. Plot No. 206. Residue, phosphorus, lime.
Soil No. 8. Plot No. 207. Manure, phosphorus, lime.

TABLE 16.—RATE AND EXTENT OF SOLUBILITY OF CORNELL SOILS AT OPTIMUM MOISTURE CONTENT. KEPT MOSTLY OUTDOORS. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	10	30	60
	C°	C°	C°	C°
Soil No. 1	.009	.012	.016	.023
Soil No. 2	.009	.012	.017	.023
Soil No. 3	.009	.012	.017	.023
Soil No. 4	.009	.012	.017	.023
Soil No. 5	.009	.012	.018	.023

Soil No. 1. Plot No. 720. No fertilizers.
Soil No. 2. Plot No. 721. 160 pounds nitrate of soda, 80 pounds muriate of potash, 320 pounds acid phosphate.
Soil No. 3. Plot No. 728. 640 pounds nitrate of soda, 80 pounds muriate of potash, 320 pounds acid phosphate.
Soil No. 4. Plot No. 730. No fertilizers.
Soil No. 5. Plot No. 732. 20 tons farm manure.
These soils were taken from plats used in rotation of timothy 3 years; corn, oats and wheat. Fertilizers have been applied each to the three years of timothy, but no fertilizer has been given to the grain crops. On the manured plat, the manure has been applied twice to the three crops of timothy instead of three times as in the case of the common fertilizers.

An examination of all the foregoing data reveals immediately and conclusively the remarkable facts (1) the rate of solubility of all the different experimental soils is very slow, the freezing point depression increasing only about .003° C in ten days and about .030° C in sixty days; (2) the extent of solubility or the total amount of material going into solution is also small, the total depression at the end of sixty days amounting in the majority of soils to only .030° C; and (3), there is practically no difference either in the rate or extent of solubility between different soils within the same group or different groups. In other words both the rate and extent of solubility of all the soils are practically the same irrespective of their fertilizer treatment.

These results are certainly very surprising when they are considered from the known crop-producing or fertility standpoint of the soils. The past crop-producing history of these soils shows that there is a very marked difference in the amount of crops produced between the various soils within any one experimental field. Thus, the soils which have received no fertilizer have yielded the smallest amount of crops, while the soils which have received a large and proper treatment of fertilizer produced the highest yields of crops. Yet all these same soils have allowed practically the same amount of material to go into solution. It would naturally be expected that the most productive soils would yield soluble material at a greater rate and in larger amounts than the less productive soils, but such was not the case. Even the Illinois soils which showed a rather remarkably close relationship between their solubility product and their fertilizer treatments at the high moisture content, failed to show a relationship at this optimum moisture content.

While these results may appear exceedingly surprising and almost incredible yet when the principles previously established or discussed are reached, they may not appear so surprising or incredible. It was shown in the previous phases of the work (1) that the presence of phosphorus

and even the salt of $Ca(NO_3)_2$ tends to have a depressing effect upon the solubility of soils. (2) A high concentration also tends to have a depressing effect upon the solubility of soils. (3) The soil material going into solution is slow in rate and small in amount and unless the soil is very heavily fertilized or is exceedingly rich its rate and extent of solubility is not very much different from that of a medium productive soil. (4) The productivity or fertility of a soil is not determined only by the amount of material going into solution but also by the kind of material, i. e., whether it is composed of all the essential plant food elements and probably in the proper amounts; and (5) The plant exerts probably itself some influence in obtaining plant food directly from the soil particles.

It is rather surprising to note that there is a closer connection between the factor of solubility and crop productivity in the various soils when the water content is maintained at a supersaturation point than at the optimum point.

Finally, it must be stated that the results of this phase of the investigation go to emphasize the principle already announced that the solubility factor is not always an absolute and reliable criterion for the state of fertility of soils. A high solubility, however, may be generally regarded, but not always as indicative of high state of fertility.

Rate and Extent of Solubility of Soils, Treated with Acids and then Washed Until all the Free Soluble Acids were Eliminated. Rate of Soil to Water was about 1 to .7 and Mixture Maintained at Room Temperature.

Having studied the effect of salt treatment upon the rate and extent of solubility the desire arose to investigate the effect of acid treatment upon the rate and extent of solubility. Accordingly, five different soils were treated with seven different acids and washed until all the free soluble acids were eliminated as indicated by the exceedingly small depression of the freezing point of the washed soils. The washed soils were then placed in the freezing point tubes, their water content being brought to the ratio of about 1 of soil to about .7 of water and their freezing point depression determined immediately and as often, thereafter, as was deemed necessary. The soils consisted of a clay loam, two brown silt loams, one fine sandy loam and one sand. These soils are the same as those used in the case of the salt treatments. The acids comprised HNO_3 HCl, H_2SO_4, H_3PO_4, $H_2C_2O_4$, $C_4H_6O_6$, and $C_6H_8O_7$. These acids were used in tenth normal strength. The treatment consisted of treating 50 grams of air-dry soil with 150 c.c. of the acid, allowing the mixture to stand for about 24 hours with occasional shaking, and then washing the soil free of acids. The experimental data obtained in this phase of the general investigation are shown in tables 17 to 20 inclusive.

TABLE 17.—RATE AND EXTENT OF SOLUBILITY OF CLAY LOAM TREATED WITH ACIDS AND THEN WASHED UNTIL ALL FREE SOLUBLE ACIDS WERE ELIMINATED RATIO OF SOILS TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	1	4	6	8	12	15	26	37	55	81
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
HNO_3	.003	.018	.020	.020	.020	.020	.020	.021	.022	.022	.023
HCl	.003	.018	.020	.020	.020	.020	.020	.021	.022	.022	.023
H_2SO_4	.003	.018	.020	.020	.020	.020	.020	.021	.022	.022	.023
H_3PO_4	.008	.018	.020	.020	.021	.021	.021	.021	.025	.033	.035
$H_2C_2O_4$	.010	.018	.021	.025	.039	.041	.072	.110	.110	.112	.090
$C_4H_6O_6$	.008	.012	.020	.020	.020	.021	.032	.035	.042	.042	.043
$C^6H^8O^7$	.008	.017	.030	.031	.034	.038	.038	.037	.037	.035	.028
Check	.010	.018	.020	.025	.029	.037	.037	.038	.040	.040	.042

TABLE 18.—RATE AND EXTENT OF SOLUBILITY OF DARK BROWN SILT LOAM TREATED WITH ACIDS AND THEN WASHED UNTIL ALL FREE SOLUBLE ACIDS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	2	5	21	42	70
	C°	C°	C°	C°	C°	C°
HNO_3	.005	.013	.018	.022	.022	.022
HCl	.005	.013	.018	.022	.022	.022
H_2SO_4	.004	.013	.020	.022	.022	.022
H_3PO_4	.008	.033	.036	.035	.035	.034
$H_2C_2O_4$	.005	.013	.026	.048	.099	.090
$HC_2H_3O_2$	.005	.028	.036	.038	.045	.043
$H_3C_6H_5O_7$	.005	.035	.050	.045	.040	.035
Check	.005	.013	.026	.039	.052	.055

TABLE 19.—RATE AND EXTENT OF SOLUBILITY OF BROWN SILT LOAM TREATED WITH ACIDS AND THEN WASHED UNTIL ALL FREE SOLUBLE ACIDS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment. Days.	0	1	2	3	5	7	9	12	21	42
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
HNO_3	.007	.013	.016	.017	.018	.020	.020	.020	.020	.022
HCl	.007	.016	.017	.020	.020	.020	.020	.020	.022	.024
H_2SO_4	.007	.019	.020	.019	.021	.022	.022	.022	.022	.025
H_3PO_4	.007	.023	.028	.028	.029	.030	.030	.030	.030	.029
$H_2C_2O_4$	.007	.012	.013	.013	.013	.019	.020	.025	.072	.127
$HC_2H_3O_2$	.007	.012	.018	.016	.018	.021	.025	.030	.040	.039
$H_3C_6H_5O_7$	.007	.022	.028	.036	.052	.079	.080	.077	.072	.057
Check	.007	.012	.019	.020	.020	.030	.035	.035	.037	.041

TABLE 20.—RATE AND EXTENT OF SOLUBILITY OF FINE SANDY LOAM TREATED WITH ACIDS AND THEN WASHED UNTIL ALL FREE SOLUBLE ACIDS WERE ELIMINATED. RATIO OF SOIL TO WATER WAS 1 TO 0.5 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Treatment Days.	0	3	5	9	11	21	52	77
	C°	C°	C°	C°	C°	C°	C°	C°
HNO_3	.004	.010	.015	.015	.015	.015	.018	.020
HCl	.004	.010	.015	.015	.015	.018	.020	.020
H_2SO_4	.004	.010	.015	.015	.017	.018	.020	.020
H_3PO_4	.005	.011	.015	.015	.018	.018	.020	.020
$H_2C_2O_4$	.005	.016	.016	.018	.018	.025	.030	.035
$HC_2H_3O_2$	.006	.011	.015	.015	.017	.020	.020	.021
$H_3C_6H_5O_7$	.005	.010	.015	.013	.015	.020	.020	.022
Check	.004	.010	.013	.017	.019	.035	.038	.040

TABLE 21.—RATE AND EXTENT OF SOLUBILITY OF SAND TREATED WITH ACIDS AND THEN WASHED UNTIL ALL FREE SOLUBLE ACIDS WHERE ELIMINATED. RATIO OF SOIL TO WATER WAS 1 TO .4 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENS FREEZING POINT DEPRESSION.

Treatment. Days.	0	4	5	13	19	21	30	60	90
	C°	C°	C°	C°	C°	C°	C°	C°	C°
HNO_3	.003	.003	.004	.005	.005	.006	.006	.009	.010
HCl	.003	.003	.004	.005	.005	.007	.007	.009	.010
H_2SO_4	.003	.003	.004	.005	.005	.007	.007	.009	.010
H_3PO_4	.004	.004	.004	.006	.006	.006	.006	.008	.008
$H_2C_2O_4$	.003	.003	.003	.004	.004	.005	.007	.007	.009
$HC_2H_3O_2$	.003	.003	.004	.004	.006	.006	.007	.001	.006
$H_3C_6H_5O_7$	.003	.003	.003	.004	.005	.005	.007	007	.009
Check	.003	.003	.003	.004	.007	.007	.008	.009	.010

The above data show that in the case of the inorganic acids the rate of solubility is rather rapid, equilibrium being reached in many cases in the first three or four days, and the extent of solubility is quite small, the freezing point depression not exceeding .025°C in the heavy type of soils, and about 010°C in the sand, at the end of about 80 days. The extent of solubility in the case of phosphoric acid treatment is slightly greater than that of the other inorganic acid treatments. In the case of the organic acids the results are somewhat inconsistent but they indicate that the rate of solubility is also rather rapid but the process goes on for a much longer time and the extent of solubility is very large and especially in some cases. Thus, in table 17 the depression rose in the case of $H_2C_2O_2$ from .010° to .112°C in 55 days. After a certain length of time the depression of some of these organic acid treatments begins to decrease, indicating that the material is going out of solution. This reverse action is similar to that in the case of the $(NH_4)_2SO_4$ treatment.

From various standpoints these results with the various acids are very interesting and very instructive.

Rate and Extent of Solubility of Natural or Untreated Soils Which Were Previously Washed Until All Free Soluble Salts Were Eliminated. Ratio of Soil to Water Was About 1 to .7 and Mixture Maintained at Room Temperature.

Having established certain fundamental principles with the salt, fertilizer and acid treatments on the rate and extent of solubility of soils, the investigation on the rate and extent of solubility of natural or untreated soils is now in order.

This part of the investigation comprised a great number of soils, coming from several different states, and including many different types and nearly all the various classes. It was the purpose in this research to study the effect of type, class, origin, fineness of particles, organic matter content and many other factors upon the rate and extent of solubility of soils. The procedure of preparing the soils and measuring the rate and extent of solubility were the same as before, namely, the soils

were washed with distilled water until all their free soluble salts were eliminated and then samples of these washed soils were placed in glass tubes, then water content was brought up to the ratio of 1 of soil to .7 water and then freezing point depression determined as usual at various intervals. The results obtained are tabulated in table 22. The typical results of a few soils are graphically represented by figures 6 to 10 inclusive.

TABLE 22.—RATE AND EXTENT OF SOLUBILITY OF NATURAL SOILS IN DISTILLED WATER WHEN THE RATIO OF SOILS TO WATER IS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

	Days.	0	1	2	4	6	8	11	15	20	28	32	39	47	67	81	99
		C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
1	Wisconsin Superior clay	.006	.008	.010	.014	.014	.014	.015	.017	.018	.020	.021	.022	.022	.022	.022	.023
2	Lufkin clay	.006	.008	.009	.011	.015	.015	.018	.022	.023	.023	.023	.025	.025	.025	.026	.027
3	Texas Houston clay	.006	.008	.010	.010	.012	.012	.013	.019	.020	.020	.022	.022	.022	.023	.025	.026
4	Georgia Cecil clay	.005	.006	.006	.007	.008	.009	.009	.010	.010	.010	.010	.010	.011	.010	.010	.011
5	Vernon clay loam	.006	.008	.010	.017	.018	.022	.020	.020	.021	.022	.022	.022	.021	.022	.023	.023
6	Clay loam	.006	.008	.007	.010	.012	.014	.014	.018	.019	.022	.022	.022	.022	.025	.026	.026
7	California Romona clay loam	.006	.008	.009	.010	.010	.010	.011	.016	.018	.020	.023	.022	.022	.022	.022	.023
8	Michigan clay loam	.006	.008	.009	.010	.011	.016	.017	.021	.026	.029	.031	.031	.031	.031	.032	.032
9	Michigan clay loam	.006	.008	.017	.020	.025	.026	.030	.037	.041	.042	.051	.049	.050	.051	.052	.052
10	Kentucky clay loam	.010	.016	.018	.020	.025	.029	.032	.038	.037	.038	.041	.040	.040	.040	.041	.042
11	Michigan brown silt loam	.006	.008	.013	.015	.027	.032	.037	.036	.037	.041	.044	.046	.048	.049	.050	.050
12	Michigan brown silt loam	.007	.008	.010	.012	.018	.023	.027	.037	.038	.039	.041	.042	.043	.045	.045	.046
13	Wisconsin Carrington silt loam	.007	.007	.010	.015	.016	.016	.018	.020	.023	.033	.033	.034	.033	.034	.034	.035
14	Wisconsin Miami silt loam	.006	.008	.010	.015	.020	.024	.024	.032	.036	.045	.046	.046	.046	.046	.047	.048
15	Wisconsin Colby silt loam	.007	.008	.009	.013	.013	.016	.018	.019	.020	.029	.031	.030	.030	.035	.035	.030
16	Pennsylvania silt loam	.006	.008	.010	.010	.012	.018	.019	.029	.033	.040	.042	.042	.043	.043	.044	.044
17	Pennsylvania silt loam	.006	.008	.009	.010	.012	.012	.016	.021	.021	.028	.028	.034	.039	.039	.040	.040
18	Pennsylvania silt loam	.006	.008	.010	.010	.013	.013	.017	.024	.032	.035	.038	.039	.039	.038	.040	.040
19	Memphis silt loam	.006	.008	.010	.012	.012	.013	.013	.013	.013	.012	.013	.012	.012	.013	.013	.013
20	Missouri Summit silt loam	.006	.008	.010	.015	.015	.022	.020	.030	.031	.030	.013	.033	.033	.034	.036	.038
21	Indiana Miami silt loam	.006	.008	.010	.017	.018	.020	.020	.021	.023	.023	.024	.025	.028	.028	.030	.030
22	Ohio silt loam	.006	.008	.009	.009	.010	.010	.010	.010	.011	.010	.010	.010	.011	.010	.010	.011
23	Ohio silt loam	.006	.009	.010	.011	.015	.019	.025	.028	.028	.030	.030	.032	.034	.035	.031	.041
24	Ohio silt loam	.006	.009	.009	.009	.010	.010	.011	.013	.013	.015	.014	.015	.015	.017	.020	.023
25	Kentucky Carrington loam	.006	.008	.010	.012	.013	.015	.016	.017	.018	.028	.029	.029	.030	.035	.038	.040
26	California Okley fine sandy loam	.003	.004	.006	.006	.008	.008	.009	.009	.010	.010	.010	.010	.010	.011	.010	.010
27	California Hanford fine sandy loam	.003	.005	.006	.006	.006	.007	.010	.010	.010	.016	.016	.017	.020	.021	.022	.021
28	Texas Vernon fine sandy loam	.003	.005	.007	.007	.008	.010	.010	.010	.010	.010	.011	.013	.012	.013	.015	.015
29	Mississippi Norfolk fine sandy loam	.003	.009	.010	.013	.015	.018	.020	.020	.021	.021	.022	.022	.022	.021	.022	.022
30	Alabama Dekalb sandy loam	.003	.005	.005	.007	.008	.008	.009	.008	.009	.009	.009	.008	.009	.010	.010	.010
31	Michigan sandy loam	.003	.006	.010	.012	.015	.017	.019	.024	.027	.032	.031	.032	.033	.035	.036	.037
32	Wisconsin Plainfield sand	.003	.004	.004	.005	.005	.005	.007	.009	.010	.010	.010	.010	.010	.011	.011	.010
33	Alabama Norfolk sand	.003	.005	.005	.008	.009	.009	.009	.009	.009	.008	.009	.010	.010	.010	.010	.079
34	Quartz sand	.001	.002	.003	.002	.003	.003	.005	.005	.005	.007	.007	.007	.009	.009	.010	.010
35	Peat	.003	.005	.005	.005	.005	.006	.007	.008	.009	.009	.010	.010	.014	.014	.015	.015

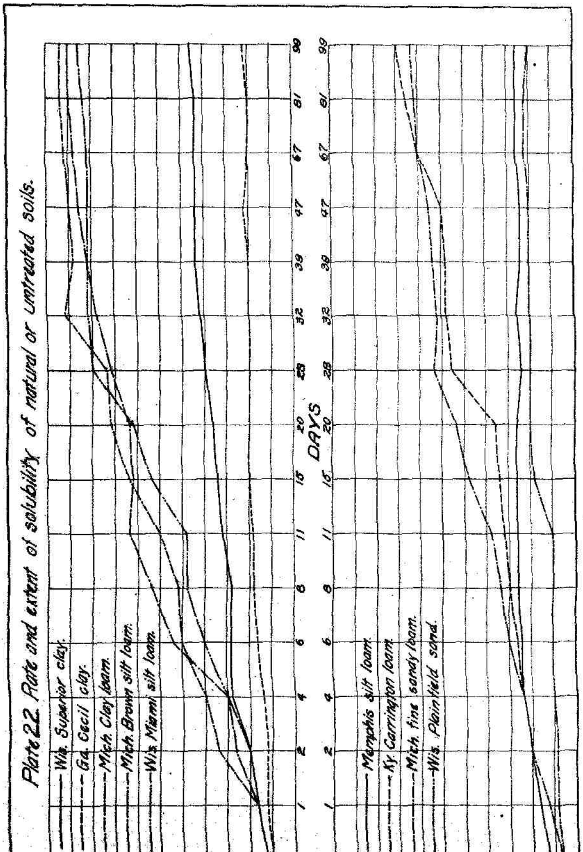


Plate 22 Rate and extent of solubility of natural or untreated soils.

A close and thorough examination of the above data reveals many interesting and important facts. First of all it is shown that there is wide difference both in the rate and extent of solubility in the various soils. In many soils the rate of solubility is slow and gradual and the process continues a long time, but usually for about 30 or 40 days and the extent of solubility is rather appreciable. Thus, in soils Nos. 9, 10, 11, 12, 14, 16, etc., the depression rises slowly and gradually from about .007° C to about .040° C in 30 days and to about .050° C in 99 days. In many other soils the rate of solubility is also slow and gradual and the process continues for a long time, but the extent is not large. Thus, in soils Nos. 1, 2, 3, 5, 6, 7, 8, 21, etc., the freezing point depression rises from about .006° C to about .020° C at the end of 30 days, to about .025° C at the end of 99 days. In still other soils the rate is not only very slow, but the extent is also extremely small. Thus, in soils No. 4, 19, 22, 26, 32, etc., the freezing point lowering rises from about .006° C to only .010° C at the end of 99 days.

The data fail to show any close and consistent correlation between the class of soil and the solubility factor or the total amount of material going into solution. Beginning first with the clays it is at once seen that the final depression varies from .010° C in the case of Georgia Cecil clay, to .023° in Wisconsin Superior clay, to .026° in Texas Houston clay.

Considering next the clay loam it is readily observed that the lowering of the freezing point varies from .023° in the case of California Ramona clay loam (No. 7) to .032° C in Michigan clay loam (No. 8) to .052° C in Michigan clay loam (No. 9).

In the case of the silt loams the variation in the depression ranges from .013° in the case of Memphis silt loam (No. 19) to .040° in Pennsylvania silt loam (No. 17) to .050° in Michigan brown silt loam (No. 11).

Even in the sandy loams the variation is quite striking. Thus, Alabama Dekalb sandy loam (No. 30) gives a depression of only .010 while Michigan fine sandy loam gives a depression of .037° C or a difference of .025° C.

The variation in the sands is very negligible. The depression of the freezing point of sands used is about .010° C for all of them.

It is conclusively evident, therefore, that there is no relationship between the solubility factor or amount of material going into solution and the class of soil.

It is also evident that soils with the greatest surface or fineness of particles do not have the greatest solubility product. Of all the soils employed the clays must possess the greatest surface, with the possible exception of peat, yet the solubility product of these soils is smaller than that of clay loams and silt loams, and in some cases it is only as great as that of sands.

It may appear that soils with large amounts of organic matter content yield the largest amount of material in solution. While this may be true in many soils yet there are many soils which contain a large amount of organic matter which did not give a high solubility product. Soils Nos. 3, 20, 15, 35, etc., may be cited as examples, while soils Nos. 14, 16, 31, etc., contained very little organic matter and yet they yielded a high solubility product. It appears that if organic matter influences the solubility it is not so much its quantity as it is its quality, as many

mucks and peats allowed only a very small amount of material to go into solution.

Georgia Cecil clay (No. 4), Memphis silt loam (No. 19), and Ohio silt loam (No. 22) need special attention. All these soils show an exceedingly slow rate and a very small extent of solubility. In these respects they resemble very much the pure sandy soils or quartz sand. The Cecil clay refused to yield more material to solution even when its temperature was raised to 53°C and kept there for 30 days.

Rate and Extent of Solubility of Natural or Untreated Soils. Moisture Maintained at Optimum Content and Soils Kept Mostly Outdoors.

In the preceding study the rate and extent of solubility of the natural or untreated soils were measured at the water content of supersaturation. In the present study it was decided to measure these factors at the optimum moisture content and thus under more or less practical or field conditions. In order to afford a true and reliable basis of comparison in the results between the two sets of moisture content the same kind of soils were used in both cases. The procedure employed in a previous study was also used here. It consisted of placing a certain amount of soil on a filter paper in a funnel and washing until all its free soluble salts were eliminated. Then a small sample of the washed soil was taken air-dried, and its freezing point depression determined by using 15 grams of soil and 10 c.c. of water. The rest of the soil was allowed to remain in the funnel undisturbed and to lose water until its moisture content was reduced to about the optimum point. Then the soil was placed in a glass tumbler, thoroughly stirred and weighed. Water was added to it, thereafter, as often as it was deemed necessary in order to keep it at the optimum moisture content. Meanwhile, the soil was kept outdoors, under as natural conditions as possible, most of the time. At the end of 10, 30, and 60 days a small composite sample was taken, air dried, and its freezing point depression determined as originally.

The results procured in this study are presented in table 23. The number of each soil corresponds to the number in table 22 where the high moisture content was employed.

TABLE 23.—RATE AND EXTENT OF SOLUBILITY OF NATURAL SOILS, AT OPTIMUM MOISTURE CONTENT. KEPT MOSTLY OUTDOORS. FIGURES REPRESENT FREEZING POINT DEPRESSION.

	Days.	0	10	30	60
		C°	C°	C°	C°
9	Michigan clay loam	.008	.013	.032	.037
11	Michigan brown silt loam	.008	.016	.029	.035
12	Michigan brown silt loam	.008	.013	.030	.035
1	Wisconsin superior clay	.007	.010	017	020
14	Wisconsin Miami silt loam	.006	.013	.021	.037
13	Wisconsin Carrington silt loam	.006	.013	.021	.036
8	Michigan clay loam	.007	.013	.023	.029
31	Michigan fine sandy loam	.006	.013	.022	.027
35	Peat	.004	.009	.013	.015
	Sand	003	009	009	.010

These results show that at the optimum moisture content the rate of solubility is slow and the extent of solubility is small, of all the natural or untreated soils. Considering first the rate, it is at once seen that the depression rises only from about .008° to about .013° in ten days to about .035° C in sixty days. In some of the soils and especially in the sands the rate is still slower. Considering next the extent, it is immediately observed that the amount of material that went into solution is comparatively small. The maximum depression at the end of sixty days in any soil is only .037° C or 925 parts per million of solution. In several of the soils the quantity is still smaller and in the case of the sand and peat it is less than 375 parts per million.

Comparing now the total amount of material that went into solution at the two different sets of moisture content it is seen that the quantity is somewhat greater and, especially in some soils, at the water content of supersaturation. Thus, at the high moisture content the freezing point depression of soils Nos. 9, 11, 12, 14, and 31 is .051°, .049°, .045°, .460°, and .035° C, respectively. While at the optimum moisture content the depression for the same soil in the order named is .037°, .035°, .035°, .037° and .027° C, respectively. The difference, therefore, in some of the soils, is as great as .014° depression in favor of the high moisture content.

The order of extent of solubility of the various soils is not exactly the same at the two sets of moisture contents. In other words, the soils which gave the largest solubility product at the high moisture content did not do it also at the optimum moisture content. The deviation in the order is not very great, but it cannot be stated that there is an absolute correlation.

Rate of Solubility of Natural or Untreated Soils Which Were Previously Washed Until All Their Free Soluble Salts Were Eliminated. Ratio of Soil to Water was About 1 to .7 and Mixture Maintained at the Temperature of 53° C.

In all of the foregoing series of experiments the rate and extent of solubility of soils under various conditions and treatments were measured at room temperature. Now it is known that temperature influences solubility. Furthermore, the temperature of the soil under field conditions changes very markedly during the various seasons of the year. It appeared very desirable, therefore, to investigate the influence of temperature upon the rate and extent of solubility. For this purpose two sets of temperatures were used, 53° C, and below freezing. The investigation at the temperature 53° C will be considered first. The procedure consisted of placing washed soils in the freezing point tubes, adding water to them to bring up the water content to the ration of 1 of soil to .7 of water, determining the freezing point, stopping the tubes with rubber stoppers, and placing these tubes containing the soils in a constant temperature oven whose temperature was maintained at about 53° C. At various intervals these tubes were taken out, opened, their contents stirred and their freezing point depression determined again. In order to prevent any pressure being produced by the raising of the temperature the tubes were opend a few minutes after they were in the temperature oven. The process of opening the tubes and stirring the contents also tended to eliminate the accumulation of any gas that might be pro-

duced in the soil and thus influence the freezing point depression. There were in all 16 soils employed. These soils represent several different types and practically all the various classes. In order to afford a basis of comparison these soils were taken from the same samples as the soils in table 22. To ascertain the influence of high temperature upon the rate and solubility of soils, therefore, the results in table 22 must be taken as basis for comparison. The data obtained are shown in table 24. The number of each soil corresponds to the similar soil in table 22.

TABLE 24.—RATE AND EXTENT OF SOLUBILITY OF NATURAL SOILS IN DISTILLED WATER WHEN THE RATIO OF SOIL TO WATER IS ABOUT 1 TO .7 AND MIXTURE MAINTAINED AT THE TEMPERATURE OF 53° C. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	1	2	3	5	9	16	24	34	42	66
	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
1 Wisconsin Superior clay	.010	.023	.025	.025	.026	.031	.031	.030	.031	.030	.031
2 Georgia Cecil clay	.006	.007	.009	.010	.010	.010	.010	.011	.010	.010	.011
3 Texas Houston clay	.008	.017	.015	.020	.020	.070	.022	.025	.025	.025	.028
4 La. Lufkin clay	.008	.010	.012	.017	.020	.020	.021	.021	.021	.024	.026
5 Michigan clay loam	.010	.023	.028	.039	.040	.045	.048	.049	.050	.051	.055
6 Michigan clay loam	.010	.033	.042	.045	.052	.058	.060	.063	.063	.065	.068
7 California Ramona clay loam	.010	.020	.025	.030	.034	.034	.034	.035	.035	.034	.036
8 Michigan silt loam	.010	.023	.034	.040	.043	.044	.045	.047	.050	.050	.054
9 Michigan silt loam	.010	.033	.040	.046	.052	.055	.060	.066	.067	.067	.070
10 Michigan silt loam	.010	.030	.041	.046	.052	.055	.056	.058	.058	.060	.064
11 Wisconsin Miami silt loam	.010	.025	.030	.035	.038	.038	.041	.044	.048	.049	.050
12 Missouri Summit silt loam	.008	.015	.017	.025	.025	.035	.035	.036	.035	.036	.038
13 Texas Vernon fine sandy loam	.006	.020	.021	.030	.032	.035	.035	.035	.035	.035	.035
14 California Hanford fine sandy loam	.010	.079	.023	.022	.026	.031	.030	.030	.030	.030	.032
15 California Okley fine sandy loam	.005	.008	.009	.010	.010	.010	.010	.012	.012	.012	.013
16 Michigan fine sandy loam	.008	.023	.032	.034	.038	.039	.042	.048	.050	.050	.010
17 Michigan fine sand	.005	.006	.006	.007	.006	.007	.006	.007	.009	.009	.052
18 Peat	.008	.010	.010	.015	.016	.018	.020	.020	.020	.020	.030

From a careful comparison of the data in the above table with that in table 22 it becomes at once evident that the temperature of 53°C influenced quite appreciably both the rate and extent of solubility, and especially of certain soils. It is readily seen that the rate was considerably hastened and the extent quite appreciably increased, on practically all the soils.

The process of solubility continues for a long time even 60 days, but the major portion of the material goes into solution the first three or four days. Even at the end of the first day the solubility product of many soils is rather large. The final total amount of material that went into solution varies tremendously in the various soils. It ranges from a depression of .010° in sand (No. 17) to .011° in Cecil clay (No. 4) to .013° in Okley fine sandy loam (No. 26) to .038° in silt loam (No. 14) to

.054° in Michigan clay loam (No. 8), to .064° in Michigan brown silt loam (No. 12) to .070°C in Michigan brown silt loam.

The influence of the high temperature on the solubility is very different in the various soils. In some soils it is very marked and in others hardly perceptible. In all of the clays, in all the sands and in a few sandy loams the influence is rather small, the difference in depression being only about .010°, while in practically all the clay loams, silt loams, and a few sandy loams the influence is rather large, amounting to a difference of depression of over .025°C in some cases. While many of the soils, in which the solubility product was greatly increased by the high temperature, contained a high organic matter content, there are few soils which contained only a very small amount of organic matter and yet their solubility product was also greatly increased. Thus, fine sandy loam (No. 31), Hanford fine sandy loam contained only a small amount of organic matter and yet the amount of material that went into solution was greatly increased. Hence, it is not only organic matter which is materially affected by the high temperature but also some other soil constituents. Undoubtedly, however, the organic matter was affected the most.

It is interesting to note the Cecil clay even at the temperature of 53°C gave no more material to solution than at the room temperature and that it attained equilibrium rather quickly. The amount of material that this soil allowed to go into solution at this high temperature is exceedingly small, amounting only to about 250 parts per million.

Rate and Extent of Solubility of Natural or Untreated Soils Which Were Previously Washed and Ratio of Soil to Water was About 1 to .7 and Mixture Maintained Below Freezing Temperature.

Having presented the investigation on the effect of high temperature on the rate and extent of solubility of soils, the influence of low temperature on these same factors are now in order.

This study was conducted by putting washed soils in the freezing point tubes with a water content of 1 of soil to .7 of water, determining the freezing point depression, then stoppering the tubes, placing them outdoors in the cold weather and then at the end of 30 days the soils were thawed and their freezing point depression again determined. The soils were placed outdoors during the month of January when the temperature for the whole month was always below freezing and most of the time at or below zero Fahrenheit. At no time did the temperature rise sufficiently to thaw the soils. The soils, therefore, remained frozen during the whole period. The soils used were the same as in the preceding study. The results obtained are shown in table 25.

TABLE 25.—RATE AND EXTENT OF SOLUBILITY OF NATURAL SOILS IN DISTILLED WATER WHEN THE RATIO OF SOILS TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT OR BELOW ZERO TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

	Days.	0	30
		C°	C°
1	Wisconsin Superior clay	.010	.010
9	Michigan clay loam	.013	.015
6	Michigan clay loam	.009	.010
7	California Ramona clay loam	.009	.010
8	Michigan clay loam	.010	.011
11	Michigan brown silt loam	.011	.011
14	Wisconsin Miami silt loam	.011	.011
12	Michigan brown silt loam	.010	.011
31	Michigan fine sandy loam	.010	.010
26	California Okley fine sandy loam	.008	.008

A glance at the above data reveals at once the fact that when the soils remain frozen no material goes into solution. It is seen that the depression of the freezing point at the end of 30 days is exactly the same as that at the beginning.

At this point some very important practical conclusions can be drawn from the entire investigation thus far presented. It has been seen that the soluble salts of the soil can be so thoroughly washed, or leached away that the soil for the time being is almost devoid of soluble salts. It has also been seen that the rate of solubility is so exceedingly slow and especially at optimum moisture content, that the soil requires not only days but even weeks to accumulate any appreciable amount of salts. Finally, it has been shown that when the soils are frozen the solubility process completely and entirely ceases.

From these facts the practical conclusions that can be drawn are that during the fall months when the rainfall is very abundant, at least in many regions, the soils are quite thoroughly washed and become almost devoid of soluble salts. During the winter months when these soils freeze, the solubility process is entirely stopped, and consequently there is no accumulation of any soluble salts. In the spring months, on account of the low temperature and the exceedingly slow rate of solubility the amount of material that goes into solution is very small and the amount of nitrates formed also small, and consequently the plants do not find an abundance of plant food in solution. This should and probably does have an important bearing on soil fertilization that is with respect to the time, amount and form to apply.

Rate and Extent of Solubility of Natural Soils Which Were Previously Washed and the Ratio of Soil to Water Was 1 to 5 and Mixture Maintained at Room Temperature.

Definite chemical compounds, at any given temperature, have a definite solubility which is independent of the relative masses of the solid and

the liquid. Now the soils are not definite compounds and the question rises, is their solubility dependent or independent of the relative masses *of the solid and the liquid.*

It was with the object of obtaining definite information upon this important point that the present investigation was undertaken. Incidentally, this information, it was thought, would throw further light upon the subject as to whether or no the solubility of the soils employed in the preceding researches has attained equilibrium. This study consisted of placing 5 grams of air-dry soil in the freezing point tubes, washing it several times by decantation and then adding to it sufficient water to bring its water content to the ration of about 1 of soil to about 5 of water. The mixture was maintained at room temperature and the freezing point depression determined in the usual way. The data obtained are shown in table 26. In order to ascertain the specific effect of the relative masses of soil and water upon the solubility, the results of the above table must be compared with the results of table 22 where the ratio of soil to water was 1 to .7. For convenience and immediate reference the soils in both tables are given the same numbers.

TABLE 26.—RATE AND EXTENT OF SOLUBILITY OF NATURAL SOILS IN DISTILLED WATER WHEN THE RATIO OF SOILS TO WATER IS ABOUT 1 TO 5 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

	Days.	0	2	4	7	16	23	32	41	53	63
		C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
1	Wisconsin Superior clay	.005	.007	.013	.012	.013	.012	.014	.013	.014	.014
4	Georgia Cecil clay	.005	.007	.010	.009	.010	.010	.011	.010	.012	.011
8	Michigan clay loam	.005	.007	.013	.016	.016	.018	.018	.018	.020	.020
9	Michigan clay loam	.005	.007	.018	.018	.020	.021	.026	.026	.027	.028
11	Michigan dark brown silt loam	.005	.007	.016	.018	.020	.022	.028	.027	.027	.027
12	Michigan dark brown silt loam	.005	.007	.016	.018	.020	.020	.020	.020	.022	.024
	Michigan dark brown silt loam	.005	.007	.012	.014	.014	.014	.018	.020	.020	.021
14	Wisconsin Miami silt loam	.005	.007	.016	.015	.016	.019	.018	.020	.020	.019
19	Mississippi Memphis silt loam	.005	.005	.008	.009	.009	.010	.016	.011	.010	.012
31	Michigan fine sandy loam	.005	.007	.010	.010	.010	.012	.013	.012	.013	.013
26	California Okley fine sandy loam	.005	.006	.010	.000	.009	.009	.009	.010	.010	.011
	Michigan fine sand	.004	.004	.004	.004	.005	.005	.004	.005	.008	.007

A comparison of the above data with the corresponding data in table 22 reveals at once the important fact that when the ratio of soil to water is 1 to 5 the solubility is much smaller than that when the ratio of soil to water is.1 to .7. Indeed, in the majority of the soils the magnitude is only half as large at the ratio of 1 to 5 as it is at the ration of 1 to .7. Thus at the end of 63 days the depression at the two ratios is as follows for the various corresponding soils:

Ratio—

1:5 .014° .011° .020° .028° .027° .024° .019° .012 .013° .011° .007° C.

Ratio—
1:7 .023° .011° .032° .052° .050° .046° .048° .013° .037° .010° .009° C.

The further significant fact to be noted in table 26 is that even though the solubility product is greatly reduced when the ratio of soil to water is 1 to 5, yet an apparent equilibrium seems to be attained at the end of about 30 days. This apparent equilibrium, however, is not attained very fast but only slowly and gradually a condition analogous to that in the other series of experiments previously reported.

It is to be concluded, therefore, that when the ratio of soil to water is 1 to 5 respectively the rate of solubility is very slow, the extent extremely small, and much smaller than that at the ratio of 1 to .7 or even at the optimum moisture content.

It would now be of interest to compare the amount of material that went into solution at the optimum water content with that at the other two water contents. These comparisons can be made in tables 22, 23 and 26. When the comparison is made it is seen that as a general rule a slightly greater amount of material went into solution when the water content was 1 of soil to .7 of water than it did at the optimum moisture content, and the least amount went into solution at the water content of 1 of soil to 5 of water. From these results it is evident that the effect of the relative masses of soil and water finds a limitation in both directions. When the ratio of soil to water is decreased the solubility product decreases, when, on the other hand the ration of soil to water is increased beyond a certain point the solubility product is again decreased.

The diminished solubility at the optimum or at any other low moisture content would probably be expected. In the first place a large portion of the moisture at the low water contents is unfree. In the second place, water in the film form may not dissolve the solid material of the soil as readily as the free and excess water. In the third place, the moisture at the low water content is not so uniformly distributed in the soil as at the high.

Rate and Extent of Solubility of Natural or Untreated Soils Previously Washed and the Ratio of Water to Soil Was 1 to 5 and Mixture Maintained at the Temperature of 53°C.

This investigation is precisely the same as the preceding one, except that in this case the temperature was maintained at 53°C. This was accomplished by keeping the soils, in the closed tubes, in a constant temperature oven of 53°C. The object of this experiment was to study the effect of high temperature upon the solubility of soils when the ratio of soil to water was 1 to 5. The results procured are presented in table 27. These results must be compared with those in table 24, where the ratio of soil to water was 1 to .7 and the temperature at 53°, in order to ascertain the effect of the relative masses of soil to water at high temperature upon the solubility of soils. To facilitate this comparison the soils in both tables are given the same numbers.

TABLE 27.—RATE AND EXTENT OF SOLUBILITY OF NATURAL SOILS IN DISTILLED WATER WHEN THE RATIO OF SOILS TO WATER IS 1 TO 5 AND THE MIXTURE MAINTAINED AT THE TEMPERATURE OF 53°. FIGURES REPRESENT FREEZING POINT DEPRESSION.

	Days.	0	2	4	7	16	23	32	41	53	63
		C°	C°	C°	C°	C°	C°	C°	C°	C°	C°
1	Wisconsin Superior clay	.005	.008	.010	.010	.012	.015	.013	.018	.018	.021
4	Georgia Cecil clay	.005	.008	.008	.008	.010	.012	.012	.013	.013	.014
8	Michigan clay loam	.005	.012	.020	.020	.021	.021	.021	.021	.022	.023
9	Michigan clay loam	.005	.015	.016	.028	.028	.029	.030	.030	.031	.031
11	Michigan dark brown silt loam	.006	.015	.017	.029	.030	.030	.031	.031	.030	.031
12	Michigan dark brown silt loam	.005	.012	.018	.029	.030	.030	.030	.030	.030	.031
	Michigan dark orown silt loam	.005	.008	.009	.010	.012	.014	.013	.013	.018	.020
14	Wisconsin Miami silt loam	.005	.008	.010	.020	.020	.022	.022	.025	.026	.028
19	Mississippi Memphis silt loam	.004	.005	.006	.009	.012	.011	.013	.013	.013	.014
31	Michigan fine sandy loam	.004	.005	.008	.010	.013	.014	.019	.018	.018	.020
26	California Okley fine sandy loam	.003	.004	.006	.007½	.010	.010	.010	.011	.011	.011
	Michigan fine sand	.003½	.003	.004½	.005	.004	.005	.006	.008	.008	.009

A critical examination of the results in the above table and of those in table 24 makes it at once apparent that even at the temperature of 53°C the solubility of the soils, when the ratio of soil to water is 1 to 5, is greatly less than that at the ratio of 1 to .7. Indeed, the degree of solubility in many soils is only one-third as great in the ratio of 1 to 5 as it is in the ratio of 1 to .7. Thus, the freezing point depression at the end of 63 days, was as follows for the various corresponding soils:

Ratio—
1:5 .021° .014° .023° .031° .031° .031° .028° .014° .020° .011° .009° C.
Ratio—
1:7 .031° .011° .054° .068° .070° .064° .038° .019° .052° .013° .010° C.

It is to be noted even at this high temperature that although the concentration is greatly lower at the ratio of 1 to 5 than it is at the rate of 1 to .7 yet an apparent equilibrium sets in at the end of about 30 days and practically no material goes into solution thereafter. It would be expected that the solubility at the ratio of 1 to 5 would continue much longer and its extent would tend to reach that of the 1 to .7 ratio, but such is not the case.

It is extremely interesting to observe that the solubility product of Cecil Clay and Memphis silt loam is extremely low and is not affected either by temperature or water content, but remains constant under all these treatments. In these respects, it acts very much like the solubility product of pure sand and quartz sand. This is a very significant fact.

The results of all the preceding series of investigations go to prove very conclusively at least one principle, namely, that when the solubility of a soil becomes constant or stationary it does not mean that absolute equilibrium has been attained or that the solution has become saturated. This conclusion becomes at once obvious from the fact that

the solubility of a soil becomes constant at the various water contents before the same extent of solubility is attained and that there is no tendency of this equality being attained, no matter how long the soil and water remain in contact. Thus, the solubility of soils in a water content of 1 of soil to 5 of water becomes constant when it is only half as great as that in the same soil at a water content of 1 of soil to .7 of water, and that no matter how long the soil is left in contact with the water, *this equality is not reached.*

From these findings the practical conclusion naturally follows that in the humid regions the soil solution never becomes saturated.

Rate and Extent of Solubility of Subsoils Which Were Previously Washed, and the Ratio of Soil to Water Was About 1 to .7 and the Mixture Maintained at Room Temperature.

All the soils employed in the foregoing series of studies were surface soils. From various standpoints it appeared very desirable to employ also subsoils in the general study on the rate and extent of solubility of soils. Accordingly, samples of subsoils at the depth of one and one-half feet were taken, washed while fresh, placed in the freezing point tubes, added water to them to bring them up to the water content of 1 of soil to .7 of water, and then the freezing point depression determined as usual. The data procured are epitomized in table 28.

TABLE 28.—RATE AND EXTENT OF SOLUBILITY OF SUBSOILS. RATIO OF SOIL TO WATER WAS ABOUT 1 TO .70 AND MIXTURE MAINTAINED AT ROOM TEMPERATURE. FIGURES REPRESENT FREEZING POINT DEPRESSION.

Days.	0	1	2	4	8	16	30	78
	C°	C°	C°	C°	C°	C°	C°	C°
Clay	.008	.015	.016	.018	.020	.020	.020	.022
Clay loam	.009	.016	.020	.020	.020	.020	.020	.022
Clay loam	.010	.018	.020	.020	.020	.020	.020	.022
Silt loam	.008	.013	.013	.013	.018	.018	.018	.020
Sandy loam	.007	.009	.009	.009	.010	.011	.011	.012
Sandy loam	.007	.010	.011	.011	.012	.011	.012	.013
Very fine sandy loam	.006	.008	.009	.009	.010	.011	.012	.013
Sand	.003	.004	.004	.004	.005	.005	.005	.007
Sandy	.003	.003	.004	.003	.005	.004	.004	.006

Apparently the rate of solubility of these subsoils is somewhat faster than that of the surface soils already considered. On the other hand, their extent of solubility is very small, amounting only to about 550 parts per million in the clays and clay loams and about 150 parts per million in the sands, at the end of 78 days.

The apparent greater rate of solubility of these subsoils over the surface soils may be partly due to the insufficient washing of the former. These subsoils were employed in the fresh condition and many of them, and especially the clays, clay loams and silt loams, were so sticky that it was impossible to wash them by the leaching process. Hence, the salts, probably were not all washed away and went into solution rather

rapidly. On the other hand, it must be stated that practically all soils which show a small solubility product like these soils do were found to give nearly always a high rate of solubility.

SUMMARY.

In the present bulletin there are presented the results of an investigation on the rate and extent of solubility of soils under different salt, fertilizer, and acid treatments, at different moisture contents, and at various temperatures; also of different types of untreated soil containing various quantities of organic matter and different degrees of fineness of particles.

The method employed in measuring the rate and extent of solubility of soils was the freezing point method. The method proved ideal for the purpose.

The general procedure of the investigation consisted of washing the treated or untreated soils with distilled water until all their free soluble substances were eliminated and their freezing point depression was very close to that of distilled water. For determining the rate and extent of solubility at the high moisture content the washed soils were placed in glass freezing point tubes, the proper amount of water being added, and their freezing point depression was determined very often for a long time. For determining the rate and extent of solubility at low moisture content the washed soils were placed in glass tumblers, after they had reached the optimum moisture content, placed outdoors under natural conditions, and their freezing point depression was determined at certain set intervals.

There were three different water contents employed, an optimum, a ratio of 1 of soil to .7 water, and a ratio of 1 of soil to 5 of water.

There were also three different temperatures used, below freezing, room temperature and 53°C.

When different classes of soil were treated with tenth normal salt solutions of $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCL, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, KH_2PO_4, $CaH_4(PO_4)_2$ and $NaC_2H_3O_2$ and then washed until all their free soluble salts were eliminated and their water content consisted of 1 of soil to .7 of water and kept at room temperature, it was found (1) that the rate of solubility of all the salt treatments except $(NH_4)_2SO_4$ was slow and gradual and the process continued for a long time even 120 days, but usually for about 50 days. In the case of the $(NH_4)_2SO_4$ treatment the velocity was quite rapid at the beginning, but it soon slowed down. At the end of about 60 days there was an apparent constancy or equilibrium in the solubility.

(2) The extent of solubility, or the amount of material that went into solution when the apparent constancy was attained is very appreciable in all the salt treatments and in all the soils, with few exceptions. All the soils except sand, treated with $NaNO_3$, KNO_3, KCL, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$ and $NaC_2H_3O_2$ yielded quite a large amount of material to solution. Thus, the depression in many cases rose from .005° to about .110°C or from 125 to 2750 parts per million of solution. The only salt treatments which did not cause a large solubility product are the $Ca(NO_3)_2$, KH_2PO_4 and $CaH_4(PO_4)_2$. The depression in some

of these salt treaments rose only from about .007° to .015°C or from 175 to 375 parts per million. As a general rule the $NaNO_3$ and $NaC_2H_3O_2$ treatments in all the soils, except sand, tended to yield the greatest solubility product, the $CaNO_3$, KH_2PO_4 and $CaH_4(PO_4)_2$ the smallest and the KNO_3, KCL, K_2SO_4, $(NH_4)_2SO_4$ and $MgSO_3$ an intermediate In many soils the $CaH_4(PO_4)_2$ and in a few cases the $Ca(NO_3)_2$ and KH_2PO_4 treatments did not only give the smallest concentration but even a smaller concentration than the check. Evidently these salts tended to have an indifferent or depressing effect upon the solubility of soils. As a whole it appears that the phosphates tend to depress solubility and that they probably act as conservers of bases under field conditions.

The results of solubility of these singly salt treated soils go to indicate *that a salt or fertilizer treatment leaves a residual effect upon the soil* and this residual effect continues to be manifested in increased solubility and in increased crop-producing power.

These data also go to indicate that the reaction between soils and salts seems to be chemical and not physical.

In view of the different residual effects that the different salts or fertilizers have upon the solubility of soils and in view of many theoretical and practical considerations, the solubility factor cannot be considered an absolute or reliable criterion for the state of fertility or crop-producing power of soils. In general, however, it can be said that a *very heavily fertilized or extremely rich soil gives a greater solubility* product than an unfertilized or poor soil.

Although the solubility attains a constancy at the end of about 60 days this constancy is not a true equilibrium. In other words, the solution is not saturated when solubility ceases. This is proven by the fact when different proportions of soil and water are employed *an apparent* equilibrium is attained in all the ratios and yet the solubility product is not at all the same when the equilibrium is reached, and it does not become the same no matter how long the soil and water in the different ratios are kept in contact. Furthermore, a consideration of the character of the soil makes it extremely doubtful if *true equilibrium can ever* be attained in the soil solution.

The solubility process of the soils would undoubtedly go on for a long *time and probably* almost indefinitely, in view of the extremely slow rate of solubility, if some factors did not intervene.

When different soils were treated with a combination of salts including $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCL, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, KH_2PO_4 $CaH_4(PO_4)_2$ and $NaC_2H_3O_2$ and washed and kept under the same conditions as the preceding, their rate of solubility was also slow, but the extent of solubility was very appreciable. In this combination the phosphates did not depress the solubility very markedly, but when the $(NH_4)_2SO_4$ and $NaC_2H_3O_2$ salts were left out from the combination then the depression became more marked.

When experimental field soils from the Experiment Stations of Illinois, Cornell, Rhode Island and Ohio, which had been receiving fertilizer treatments in the usual way, were washed, and kept at the moisture content of 1 of soil to .7 of water and at room temperature, their rate of solubility was also very slow, but their extent of solubility varied,

being rather appreciable in some of them and quite small in others, and this variation did not bear a close connection to the previous fertilizer treatment. In other words, there was no close relationship in all the groups of soils, between the amount of material that went into solution and the previous fertilizer treatment. These results are in general agreement with those of the single salt-treated soils.

Even when these same experimental field soils were kept at the optimum moisture content, and placed outdoors under natural conditions, failed to give a solubility product which bore a close relation to the previous fertilizer treatment. Again, even at the optimum moisture content the rate of solubility was very slow, but the extent of solubility was quite appreciable, but far smaller than that of the salt-treated soils.

The results of both series of studies of the field experimental soils go to emphasize the principle already announced that the solubility factor is not an absolute and reliable criterion of the state of fertility or crop-producing power of soils.

In the soils treated with acids of HNO_3 HCL, H_2SO_4, H_3PO_4, $H_2C_2O_4$, $HO_2H_3O_2$, and $C_6H_8O_7$, and washed and their moisture content was 1 of soil to .7 of water and kept at room temperature, their rate of solubility was quite rapid, but their extent of solubility varied, being very small in the case of the inorganic and slightly higher in the phosphoric acid, and quite appreciable in the organic acids.

In the natural or untreated soils, which were washed, kept at room temperature and at a moisture content of 1 of soil to .7 of water, both the rate and extent of solubility varied considerably between the different soils. In some soils both were rather appreciable, in others they were very slight. In these soils, which numbered about 50, and included nearly all the different classes and many types, there was no close and consistent relationship between the solubility factor and the class of soil, the organic matter content and the fineness of particles.

Practically the same type of results were obtained in these various types and classes of untreated soils when an optimum moisture content was employed and the soils were kept outdoors under natural conditions. In some soils more material went into solution when the moisture content was 1 of soil to .7 of water than when the moisture content was at optimum.

On the whole there was a closer relationship between the solubility factor and the state of fertility or crop producing power when the moisture content was 1 of soil to .7 of water than when the moisture content was at optimum.

When natural soils, previously washed, and having a moisture content of 1 of soil to .7 of water, were kept at a temperature of 53°C their rate of solubility was somewhat appreciably increased. In some soils, however, these factors were not at all affected by the high temperature. The solubility of many soils even at this high temperature continued for a long time, even 60 days, but usually it became constant at the end of about 30 days.

At the ratio of 1 of soil to 5 of water the rate of solubility of natural soils is also slow and the extent of solubility extremely small. In fact, the amount of material that went into solution at this water content is

only about half as great as that at the water content of 1 of soil to .7 of water, and yet an apparent equilibrium was attained at this high water content, just as it was in the lower water content.

When the soils, having a ratio of 1 of soil to 5 of water, were kept at the temperature of 53°C their rate and extent of solubility were slightly increased. The solubility product, however, was only about one-third as great as that of similar soils kept at the same temperature but having a ratio of soil to water of 1 to .7 respectively, and yet an apparent equilibrium was attained in the high ratio just as in the small ratio.

The results of the experiments wherein were used the ration of 1 of water to 5 of soil go to indicate very strongly that the concentration of the soil solution depends upon the relative masses of the soil and water *and that the soil does not possess a definite solubility like definite compounds do.*

The amount of material that goes into solution seems to increase as the ratio of soil to water is increased up to about the optimum moisture content and then it decreases.

It is thus seen, that the rate and extent of solubility of soils are affected by many soils.

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